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ARTICLES

THE ROLE OF THE UNIVERSITY IN AGRICULTURAL RESEARCH

By J. R. A. McMILLAN

The functions of a University Faculty of Agriculture are the same as those of any other professional faculty, namely, to conduct research and to provide an education at university level, and at the same time to provide a training which will enable the graduate to find employment in his profession.

One often hears the statement that a certain organization should do only fundamental research, while another organization should confine its attention to applied research. While it is easy to refer to research as fundamental or applied, it must be realised that there is no clear division. I have not heard anybody claim that the university should *not* do fundamental research. We may accept it, therefore, that not only is there no objection to the university doing fundamental work, but there is strong opinion that it should.

The question of whether the university should carry out applied work is more controversial and the opinion is strongly held in many quarters, that applied research should not be undertaken and that this should be left to other organizations such as the State Departments of Agriculture.

In 1927, a conference of representatives of the Council for Scientific and Industrial Research, the State Departments of Agriculture and the universities decided that the C.S.I.R. should undertake fundamental research and the State Governments should be responsible for applied research (C.S.I.R., 1927).

This division in which fundamental work is done by one group of institutions and applied work is done by another, is not always in the best interests of the work, for, in 1946, an Australian and New Zealand conference of Cereal Breeders and Geneticists held in South Australia resolved that

> 12. (1) "the 1927 agreement by which the Government undertook that fundamental problems of cereal breeding and genetics and the States the practical breeding programme is no longer in the best interests of either party, nor is it likely to achieve the desired results."

To overcome this difficulty it was recommended that a Committee be established responsible for the co-ordination of existing programmes of cereal breeding and the allocation of fundamental problems to the most suitable existing institution. In general it would act in an advisory capacity to the Australian Agricultural Council on these matters.

The Rural Reconstruction Commission in its sixth report in 1945, considers agricultural research in Australia and recommends that . . . "The universities should be encouraged to devote more attention to research on rural problems either on their own account or in co-operation with the Council for Scientific and Industrial Research and State

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Departments, and to this end research funds should be made available to them. Naturally such researches should not overlap those which are being carried out by other instrumentalities."

Nowhere does the Commission say that universities should confine their investigations to fundamental work.

University Research

The amount of research being undertaken by the University Faculties of Agriculture is relatively small. If these Faculties are to make an important contribution to the improvement of Agriculture they must increase their research activity very substantially. Apart from solving the problems, they need this both for the usual stimulation that research is for teaching and also for training students and young graduates in research techniques. Much of this research should be of an applied nature.

Hovde, in 1949, draws attention to the "Dual tasks of the university" and states, "The first and perhaps most fundamental role of our universities . . . is to discover individual creative talent and provide for its education and training. The process must be carried through the graduate schools until the product is ready to man research laboratories of the nation in the work of creating and applying knowledge for useful purposes.

"Secondly, an equally important role to be played by our universities is in the production of our basic understanding, theory and knowledge of nature and of man himself.

"These two tasks are intimately related and it is my belief that all research programmes of universities, whether pure or applied, should be so administered that both trained young people and new basic knowledge are the dual output.

"The universities have been historically and must continue to be fountains of new knowledge and trained people."

Ubbelohde (1951) states "Under current academic conditions, some regard can be given, at least in principle, to the relative educational values of different research projects. Young post-graduate students who are being trained in research methods have a particular claim on their university to be given access to an adequate diversity of research experience. The teaching potential of a research school may in part be assessed by the extent to which it meets this claim."

Type of Research at Universities

Traditionally a university teacher may undertake any line of research that he wishes and this is well understood in academic circles. There is nothing in his terms of appointment placing any restriction whatever on the nature of his research. There is no question that the teacher should do fundamental and not applied research. It is expected that he will pursue investigations which will increase knowledge and this may arise from applied as well as fundamental research.

Actually some university teachers prefer to undertake applied research because they feel they are closer to the problems of the community. By solving these and improving the lot of their fellow men they derive great satisfaction.

Training of Research Workers

The university is often criticised for being too critical and lacking a "down-to-earth" appreciation of the problems of agriculture. This criticism comes from farmers and graziers and from officers of the Departments of Agriculture. In the latter case claims are made that the young graduate has no idea of a practical approach to a problem, and hence the university should be more practical in its teaching.

Many graduates are required to undertake applied research. If they are to be trained at the university for this kind of research they should have ample opportunity to study methods and techniques at first hand. This could be best achieved if a considerable body of applied research

were being done by the university. Students could participate in the programmes and get the training desired. This could not be achieved by making contact with research programmes of other organisations.

Shortage of Students

There has been an alarming fall in the number of students taking Agricultural Science at the universities. At Sydney the first-year intake has fallen from 100 immediately after the war to 32 in 1953. Much of this can be attributed to the general fall in university student number and to the conclusion of ex-service training courses, but there must be other causes. It is astounding to learn that an extraordinarily small portion of the community knows that there is a course in Agricultural Science at the universities and that an even smaller group has any real appreciation of it. In the High Schools the most intelligent students are put in the two-language classes and the less intelligent are directed to Agriculture. Would parents encourage their children to do Agriculture at the university in view of this?

The way to overcome this is more publicity—and good publicity—for the Faculties of Agriculture. To achieve this there is nothing like successful scientific research, particularly if it is of an applied nature.

From Sydney the story of the work of Waterhouse and Watson in wheat breeding, with Gabo as the second most popular wheat in New South Wales and receiving record premiums for its quality, is being appreciated. The work of Breakwell, Jenkins and Crofts at Lismore on paspalum pastures is well known in the community. Vincent's work on *Rhizobia* is becoming known and will make its mark in due time. White, Baker and others will follow as their work develops. Campbell's work on Agricultural Economics is also receiving attention. Many examples from other Faculties could be quoted.

The fundamental aspects of these researches pass unnoticed by the general public. Excellent fundamental work of Breyer is well known and appreciated in scientific circles throughout the world at the present time, but it has little public appeal at this stage.

Hence I believe that if we can undertake more applied research the potentialities of the Faculties of Agriculture will be more greatly appreciated and we will get more students.

Finance

The shortage of funds in universities is well known. In 1954 the Faculty of Agriculture in Sydney will receive only £2,900 for research from the university, and this is, of course, from the Governments. True, staff salaries are paid from university funds also and in theory the staff has half-time available for research. The Commonwealth and State Governments spend money on agricultural research in New South Wales through their various Departments. In the Commonwealth the institutions are C.S.I.R.O. and the Department of Commerce and Agriculture. In N.S.W. the State Departments are Agriculture and Conservation. The amount of £2,900 available to the Faculty of Agriculture for 1954 is less than one quarter of one per cent. of all Government money spent on Agricultural Research in N.S.W. There is not much hope of increasing this amount through normal channels. Even if Government grants to universities were doubled and this were passed on, the amount available to the Faculty would be still less than £6,000 per annum.

To increase our research funds, there appear to be four possibilities:—

(i) A direct grant to the Faculty from the Commonwealth Government.

(ii) A direct grant to the Faculty from the State Government.

(iii) Grants from semi-Government and private institutions.
(iv) Support from industry.

(i) *Grants from the Commonwealth.* Under present arrangements these are likely to be extremely rare and for limited projects. The Faculty is very grateful to the Department of Commerce and Agriculture for making available £5,000 this year for pasture research on the red soils at Lismore. This was forthcoming because of the promising nature of the work and the fact that it had an immediate practical application; and also to the support received from the people of Lismore who set up a Richmond River Research Council and raised about £3,000.

The C.S.I.R.O. has provided some support for a few projects over the past seven years.

(ii) *Grants from the State.* It seems unlikely that a direct grant to the Faculty would be made from the State Government. The Government cannot meet the demands of its own Department of Agriculture.

However, the N.S.W. State Government has done two very important things to further university research. First, it has agreed to locate four research officers at the University to undertake research work of mutual interest; one officer has already commenced on frost resistance in wheat. Secondly, it has seconded one research officer and is making some labour available for the Lismore work.

(iii) *Grants from semi-government and private institutions.* These have been very helpful. Special assistance in New South Wales has been obtained from the Rural Bank, the Rural Credits Development Fund of the Commonwealth Bank, and the Bank of New South Wales. The money has been given for specific projects calling for applied research.

(iv) *Support from industry.* Dr. Forster drew attention to the necessity for this in his presidential address to Section K of A.N.Z.A.A.S. in 1952, and cited various examples. A recent example in Sydney is the gift of £8,000 from the Flour Mill Owners' Association of N.S.W. to further the University's work on quality of wheat.

Wheat growers are interested in such a possibility. Those in Western Australia have decided to levy themselves ¼d. per bushel and in N.S.W. ⅛d. per bushel—the money raised to be used for research. At present there is apparently some difficulty with regard to implementation.

In all of these cases a definite project must be submitted and the project must be for applied research—although in practice some fundamental research is of necessity worked into the programme. Applications for funds for fundamental research without an immediate application are rarely if ever supported. Hence the Faculty must engage in applied research if it is to do much research at all.

Incidentally, this method of financing has its limitations. It is always of short duration, and usually for only one year. This makes it impossible to attract and retain good personnel except in rare cases. It is also likely to be inefficient as plans have to be made and the work carried out always with the fear that it may not be possible to carry on at the end of the year.

Aid from Employers

Most professions provide some choice as to employment, for example, the graduate may become a private practitioner, an employee in industry or an employee in a Government or semi-Government service. The scope for graduates in Agricultural Science is, however, much more limited. There is practically no possibility of being a private practitioner in an advisory capacity, but the graduate may, of course, become a farmer or grazier provided he has the capital. Opportunities in private industry are not as numerous as for other

professions and hence our graduates have little option of employment outside the Government services. This is likely to be the case for many years to come.

Because of this and the fact that student numbers are declining, could not the employing organizations assist the universities in their Agricultural Research programmes?

Could not C.S.I.R.O. do much more? Even if there is need for independent units, there is no doubt that it would be to the benefit of Australia generally, and C.S.I.R.O. in particular, if much more use were made of the universities.

Conclusion

I think, therefore, that there is no justification in the claim that the universities should do fundamental and not applied research. In fact, I think there is a strong case for encouraging applied research in their Faculties of Agriculture for the following reasons:—

1. To stimulate teaching.
2. To provide adequate training in research for undergraduates and particularly young graduates.
3. To enable the Faculties of Agriculture to be brought more before the public eye and to be better appreciated by the community.
4. To attract more students to Agricultural Science.
5. To enable Faculties of Agriculture to obtain funds for research, so that they may become real research institutions and not merely teaching ones.

I think also that the main employing organizations such as C.S.I.R.O. and State Departments should collaborate more effectively with the Faculties of Agriculture to ensure that the Faculties are able to undertake adequate research programmes.

Acknowledgments

I wish to express my appreciation to Professors Prescott, Teakle, Underwood and Wadham for the views on this subject which they expressed in correspondence.

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THE IMPORTANCE AND GENETIC CONTROL OF UNDESIRABLE RECESSIVE GENES IN LIVESTOCK

By F. H. W. MORLEY

Summary

The economic importance of undesirable recessive genes depends on their frequency and their type of expression. The frequency will generally be very small, but most individuals are probably heterozygous for at least one undesirable gene. The type of expression may be variable. A large proportion of homozygous recessives are likely to die before birth, and therefore may not be noticed. Some genes, although important biologically, may be relatively unimportant economically.

Gene frequencies of undesirable recessives are normally kept at a low level by selection, heterozygote expression and inbreeding. If a gene happens to reach a high frequency, mass selection, especially if aided by progeny-tests, will soon reduce the frequency to an unimportant level. Special types of test-mating, such as sire-daughter, are unlikely to be of much additional value.

Introduction

The rapid growth of the practice of artificial insemination during recent years has focussed attention on the problem of lethal and seriously detrimental recessive factors. Discussions such as those by Cooper (1951) have rightly drawn attention to the possible dangers attached to the wide use of heterozygous sires. Unfortunately relevant data are lacking and will probably be unavailable for some generations. Nevertheless, present knowledge of population genetics may enable the dangers to be assessed with some accuracy, and perhaps special precautions or modifications of breeding plans may be evaluated.

The following questions require to be answered:—

1. What is the frequency of lethal or detrimental recessives?
2. What form of expression do these usually take?
3. How may their frequencies be kept to an unimportant level?

Frequency of Deleterious Recessives

In a large population in which the opposing forces of selection and mutation are at equilibrium, the frequency of recessive genes is of the order of u/hs where u is the mutation rate, and **aa**, **Aa** and **AA** reproduce at rates $(1-s):(1-hs):1$ (Wright 1929). If the double recessive is lethal ($s=1$), and if completely recessive ($h=0$), then the equilibrium frequency of **a** is $\sqrt{u}$. If there are $2N$ genes on N loci capable of mutating to a recessive lethal, the average number of lethals per individual is of the order of $2N\sqrt{u}$.

If each mutation is independent of other mutations in occurrence and frequency, the number of mutations per individual will be distributed in a Poisson series. Therefore, the probability of an individual carrying no recessive lethal genes will be exp. $-2N\sqrt{u}$. However, if the population is inbred, or if there is some selection against heterozygotes (h is positive), then the frequency of lethals may be much lower than $\sqrt{u}$, and the probability of an individual carrying no lethal will be correspondingly much greater. Of course, the frequency of deleterious but not lethal recessives will be higher than that of lethals, so the probability of an individual being free from these types of gene must be very small. These considerations are discussed further by Wright (1931), Haldane

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(1937), Dobzhansky and Wright (1941) and Dobzhansky (1951).

Unfortunately there are no data from domestic animals indicating the size of *s, h, N or u.* However, data from Dobzhansky and Wright (1941) and others, summarised by Dobzhansky (1951), indicate that in *Drosophila,* the number of loci capable of carrying a recessive lethal or strongly deleterious gene to be of the order of 2,000 to 5,000. Further data from several *Drosophila* populations, summarised by Prout (1952), quote estimated values of *h* of the order of 0.02. Data summarised by Haldane (1948) and Dobzhansky (1951) suggest that the mutation rate per gene per generation is of the same order (about 10^{-5} to 10^{-6}) in *Drosophila* and man. Lush (1946) summarised data on rates of inbreeding in various species of livestock, most increases in Wright's (1922) coefficients of inbreeding being approximately 0.004 per generation.

We may be justified in assuming the following to be applicable to domestic animals.

1. The number of loci capable of carrying markedly deleterious recessives is likely to be much greater than that in *Drosophila.* Wright (1950) suggested that there may be 40,000 such loci in humans. We may take a figure of 10,000 for purposes of present calculations.

2. The average mutation rate per gene per generation is about 10^{-6}.

3. Heterozgote disadvantage is probably small or absent because of improved conditions for survival which generally accompany modern methods of animal husbandry. Thus Teissier (1942) found that, although the survival rate under optimum conditions of some heterozygotes was greater than either homozygote, under conditions of strong competition for food supply these same heterozygotes showed poor fitness. Nevertheless this assumption is rather unsatisfactory especially as values of *h* even of the order of 0.02 may drastically affect equilibrium frequencies.

4. Normal rates of inbreeding are too low to affect gene frequency to an important extent.

We may therefore calculate the average number of strongly deleterious recessives ($2N\sqrt{u}$) as $20{,}000 \times 10^{-3} = 20$. The probability of an individual carrying no such recessives (exp. —20) is approximately zero. This probability may be increased to some extent if average gene frequencies were not at equilibriums appropriate to the domestic state, but at levels between these and those expected in a natural state, when selection pressure against heterozygotes and homozygotes might be more severe.

Although the assumptions regarding number of loci and mutation rates are unlikely to result in overestimates of the average number of deleterious genes per individual the value of *h* is both critical and unknown.

The evidence of Dobzhansky and Wright (1941) and Dobzhansky *et. al.* (1942) from *D. pseudoobscura* suggests that an individual from a normally cross-fertilizing population is likely to be heterozygous for at least one deleterious recessive gene. Combining the data from the three main autosomes of that species the probability of an individual being free of *lethals* is about 0.2.

The general experience of inbreeding with animals and normally cross pollinated plants provides evidence of some value. Thus Robertson (1949) summarised information on 13 lines of dairy cattle, in 10 of which harmful recessives appeared, and in two more the reduction in production was sufficient to cause the lines to be discarded. Experience with swine has not been encouraging. In poultry the results of inbreeding are usually so drastic that saving lines from extinction is frequently a major problem. In sheep inbreeding has been found to be accompanied by a decline in viability and a decrease in vigour (Morley 1954). As

Haldane 1937), Crow (1948) and Fisher (1949) have pointed out deleterious recessive genes, even if at low frequencies, could be responsible for most of the observed degeneration from inbreeding, although the general fitness of a random breeding population would not be seriously affected.

Therefore there seems to be reasonable justification for the theory that individuals free from deleterious recessive genes are likely to be rare, although the frequency of any particular gene with such properties is likely to be so low that the probability of it being recognised and reported must be small.

Form of Expression of Lethals

Relatively few lethals have been described in livestock. Lerner (1944) lists a total of 25 in cattle, 9 in pigs, 7 in sheep and 19 in poultry. These are probably only a very small fraction of the total lethals and a small proportion of "visibles". Gowen and Gay (1933) found 13.7 visible sex-linked mutations to 100 which were recessive sex-linked lethals in *D. melanogaster*. Dobzhansky *et. al.* (1952) found a similar ratio of visibles to lethals plus semi-lethals in two other species of *Drosophila*. In these studies the usual lethal expression was almost complete non-emergence of homozygous flies and death frequently occurred at embryologically critical periods. If similar findings applied in animals we might expect a large proportion of embryonic or foetal deaths among homozygotes. The findings of Brambell (1948) indicate that there is plenty of scope for the expected proportion of homozygotes (Nq^2) to die *in utero*. Pursuing the analogy, we may expect that a large proportion of lethals in poultry would be expressed before hatching. The fact that one of the strongest effects of inbreeding is on hatchability seems to support this expectation. However, the maternal environment provided for mammals is probably capable of sheltering a large proportion of "unfit" individuals until birth or later. Nevertheless, there may be numerous lethals which result in prenatal death.

The economic harmfulness of different lethals may not correspond to the biological harmfulness. Thus in dairy cattle a gene determining death before implantation would act as a lethal but would be of negligible economic importance. A gene determining death during the middle of pregnancy would be relatively serious because of the delayed freshening which would result. A gene determining death of the new-born calf would be of little economic importance (provided dystokia were not severe) because, although the calf is lost, the cow would have freshened. The economically most serious conditions are those which are not expressed until approaching maturity, but these are probably rare as, although they are most likely to be reported, few are known. In sheep or beef cattle lethals acting during early-pregnancy would be serious since a restricted mating season is usual. Genes acting before implantation would be relatively unimportant if they did not prevent a second and possibly successful mating. Different lethals, although they may be of equal biological importance [approximately equal to the mutation rate (Haldane, 1937)], may differ greatly in economic importance, and a certain type of lethal may be important in one industry but not in another.

These considerations are important in deciding whether to test-mate sires destined for use in artificial insemination. If practically all sires carry at least one lethal then there is little point in testing, except possibly for those lethals or detrimental recessives which have, by chance or wide use of carrier, reached a fairly high frequency in a breed, and which are likely to be detected by reasonably practicable matings.

How may the Frequencies of Lethals be kept at unimportant levels?

We have seen that the frequency of undesirable recessive genes has an equilibrium at about $\sqrt{u}$, but may be somewhat lower than this because of selection against heterozygotes and inbreeding. However, in some circumstances the frequency of individual undesirable genes may rise to a point where the incidence of homozygous recessives is of economic importance, even in non-inbred populations.

The most probable of these circumstances occurs where a sire has been used widely, possibly by artificial insemination, and he is followed by a number of sons. If that sire is (and he probably is) heterozygous for some undesirable recessive, and he is used on m of the population, the frequency of the gene in the following generation immediately rises to approximately $m/4$. That is $m/2$ of his offspring are heterozygous for the gene. If in the next generation sons of this sire, half of which are on the average heterozygous for the gene in question, are used on l of the females, and if inbreeding is not avoided, then $ml/16$ of the offspring of that generation may be homozygous recessives. In an A.I. centre such as described by Robertson and Rendel (1950) with 2,000 cows, half of which are inseminated to one sire, whose sons are used on half the next generation (initially for testing purposes), about 1 homozygous recessive in 64 offspring may be expected. If the original sire were heterozygous for n undesirable recessives, the expected proportion of homozygotes is $nml/16$, which may be quite important, especially if the sample of sons happens to contain much more than 50 per cent. heterozygotes. This sort of situation may be avoided if close inbreeding is avoided.

However, it is quite possible that two successive sires may both be heterozygous for the same undesirable gene even though they are not closely related. The probability of this happening by chance is approximately $4Nu$ where N is the number of loci capable of harbouring the deleterious gene and u the mutation rate. This figure is likely to be fairly small (about 1 in 25). However, it may very well happen that the sires are distantly related. Thus if they have in common one grandparent who is heterozygous for n undesirable genes, the probability that they are both not heterozygous for any of the same genes is exp.—$n/16$. If $n = 4$, this figure is 0.78. That is, over 20 per cent. of such pairs would be heterozygous for at least one gene in common. The proportion of homozygous recessives resulting from consecutive use of two such males would be $ml/8$, even though the degree of inbreeding is quite small.

Another circumstance in which the frequency of deleterious recessives may rise to an important level is where the heterozygote is favoured above either homozygote. Wright (1931) showed that the equilibrium frequencies, if **AA**, **Aa** and **aa** reproduce at $1 - t$, 1, and $1 - s$ respectively, are $s/(t + s)$ and $t/(t + s)$ for A and a respectively. Since t is unlikely to be greater than 0.1, then q_a is unlikely to be greater than 0.1, so that the frequency of lethal homozygotes will be about 1 per cent. This situation does not seem likely to be important, firstly, because the proportion of loci showing heterozygote advantage, at least in *Drosophila*, seems to be small, and secondly, because selection against **"aa"**, if markedly deleterious, would keep the frequency of **"a"** to a relatively unimportant level. Unfortunately, if we do not know the exact phenotypes for each genotype we are not in a position to reduce the frequency of such genes.

The advisability and practicability of any special breeding programme for the elimination of undesirable recessives depends on several factors. The phenotype

of the homozygote and its economic importance must be considered. If it is a "non-visible" the chances of control are diminished. The type of management practised in breeding operations—including the reliability and availability of pedigrees—determines whether anomalies will be reported. The size of the breeding unit and the structure of the population determine the level of inbreeding, and at least in the initial stages, the proportion of homozygotes expected. If a regular interchange of breeding material between units can be arranged, inbreeding can be avoided and the frequency of homozygous recessives diminished.

What measures should be taken to reduce the frequency of undesirable recessives?

Firstly, mass selection—elimination of homozygotes—will reduce the gene frequency fairly rapidly. If frequency of homozygous recessives is 10 per cent., one generation of selection will reduce this to 6 per cent., a second generation of selection to 4 per cent. Although this reduction in frequency is rapid on an evolutionary scale, a faster rate would be desirable in commercial breeding. However, the advantage of mass selection is that it prevents gene frequency from reaching a level at which it is important, except in units with relatively few parents, in which case chance changes may be of some consequence.

Where pedigrees are available two refinements are possible. Firstly, animals producing homozygous recessive offspring from normal matings can be culled, and secondly, special test matings may be used for detection of heterozygotes. If the frequency of "a" is q, then the frequency of **Aa** in the surviving population is $2q/(1+q)$. The probability of n random matings of a heterozygote producing no homozygous recessives is $\left\{\frac{1-f}{2(1+q)}\right\}^n$. This probability is given in Table I for various gene frequencies and values of n.

TABLE I.

Probability of an heterozygous individual producing progeny with no homozygous recessives among n offspring from random matings, with q at different levels.

Values of n	Values of q			
	0.1	0.2	0.3	0.4
1	.95	.92	.88	.85
10	.63	.42	.29	.22
20	.39	.17	.09	.05
30	.25	.07	.02	.01
40	.16	.03	.01	.00
50	.09	.01	.00	.00
60	.06	.01	.00	—
70	.04	.00	—	—
80	.02	—	—	—
90	.02	—	—	—
100	.01	—	—	—

If gene frequency were of the order of 0.1, about 98 per cent. of heterozygous young sires producing 90 offspring would be detected as heterozygous. Even with only 30 offspring, 75 per cent. of heterozygous sires would be detected. Under the circumstances test matings seem unjustified.

Johansson and Robertson (1952) discussed the relative efficiency of special test matings. They showed that the number of progeny required from known heterozygotes and from sire-daughter matings to detect 19 heterozygotes out of 20 was 10.4 and 22.5 respectively. Obviously the chances of accumulating sufficient heterozygotes for testing purposes depend on gene frequency. If a substantial number of known heterozygotes were available, gene frequency would be high enough for random samples to give fairly accurate results. Thus if q were 0.1, only one per cent. of females would demonstrate their heterozygosity in each mating, so the number of test matings would be restricted. However, the few known heterozygous females available

could be used to give a test of a proven and acceptable sire during his first year of use, simply to increase the probability that he is not an heterozygote to a near certainty.

The use of homozygous recessives for genes which are not biologically lethal (e.g., horn-polled) will generally be the most efficient type of test. However, as the frequency of the dominant gene approaches 1.0, the proportion of homozygous recessives will become so small that very few test matings will be possible.

The sire-daughter mating has been recommended as a possible routine operation in animal breeding. Young sires could be used on a sample of 20 to 25 of their daughters for the first mating of these. This mating has the advantage that all deleterious recessives, whether common in the general population or not, would have a 19 to 1 chance of being demonstrated. However, we have seen that most individuals are likely to carry at least one deleterious recessive, so that most individuals tested would have to be culled, if results of tests were taken at face value, assuming that all recessives were visible. This seems to have been the situation in the California studies (Mead, Gregory and Regan, 1946). The problem of the use of such a test is further complicated by the increased inbreeding which would result. In the A.I. unit discussed an average of 11 daughters each from 40 groups of sire-daughter matings would mean that 440 heifers of 3,000 born in each 3 years' period would be 25 per cent. inbred. If the decline in production were 1 per cent. for each per cent. of inbreeding (Nelson and Lush, 1950) the average loss in production would be 440 x 25/3,000 = 0.37 per cent. over the whole unit. Some of this would be offset by a greater culling rate among inbred offspring, balanced to some extent by a lower possible culling intensity among non-inbred females. The effect of a policy of mating each young sire to a sample of his daughters would not only lower expected genetic progress from 1.69 per cent. to 1.57 per cent. per annum as shown by Robertson and Rendel (1950), but would decrease actual production (not additively genetic) by a further 0.37 per cent. This is the result of a policy calculated to prevent the appearance of at most three per cent. of animals homozygous for undesirable recessives. In addition we have assumed the recessives would be detectable and that the problem of arranging the sire-daughter matings could be overcome. Both these assumptions seem very unlikely to be correct under most circumstances.

We should consider the situation where the recessive is lethal and results in pre-natal death. If the pre-natal death does not interfere with the oestrous cycle the lethal will result in a very slight loss in fertility and will be quite unimportant. If the pre-natal death does not occur until later stages of pregnancy it will be of greater economic importance, but may not be much more detectable. Calving rates from sire-daughter matings where one lethal of this type is involved would be about 12 per cent. below normal. Under most circumstances this would be insufficient to justify any decision. Consequently we must rely on mass selection against homozygous recessives to keep the frequencies of such genes to unimportant levels.

General Conclusions

We have shown that, although the frequency of deleterious recessive genes is likely to be very low, the majority of individuals probably carry at least one such gene in the heterozygous state. The damage to the fitness of a population from such genes is unlikely to be great because of their low frequency, and because many of them, although important biologically, may be relatively unimportant economically. However, their importance may be considerable if inbreeding tends to be intense, although inbreed-

ing will tend to reduce their average frequency.

The frequency of a deleterious recessive may increase by chance, or because of wide and successive use of heterozygous individuals. However, the frequency of homozygous recessives will seldom increase to more than 2-3 per cent. Under such circumstances mass selection will reduce gene frequency. If progeny-tests are available a large proportion of heterozygotes will be detected. Therefore, special test matings such as sire-daughter appear to have little potential value, and are certainly unlikely to be of sufficient value to offset their disadvantages. If the undesirable recessive determines an undetectable prenatal death the chances of consciously speeding up its elimination are small. However, such a lethal, although biologically important, may be relatively unimportant economically.

The regular and occasional appearance of individuals which are homozygous for some undesirable recessive should be recognised when comparing families, line-crosses or groups of progeny. In practically all livestock a proportion of individuals are "runts", extremely low producers or of such poor phenotype they are obviously culls. Frequently the merit of such individuals is so low that their effect on family averages may cause a sire or a line to be culled, even if the phenotype of other members of the family is quite satisfactory. Individuals such as these may reflect grossly unfavourable environments, such as early mismothering of lambs. They may also result from genes with effects so deleterious that the resulting phenotype creates a bottleneck, through which the advantages of "good" genes cannot pass. Of course the phenotype may result from a combination of genetic and environmental causes.

If the abnormality is environmental in origin, the individual should not be counted against the family. If it is determined by genes, except perhaps in cases where the particular gene is at a high frequency, we should recognise that this is just one of those improbabilities which did occur, and it should not be debited against the group average. Therefore we are probably justified on overlooking hens which lay five eggs in a year, cows which yield only 200 gallons of milk, or sheep which cut 5 pounds of wool when the average is 12 lbs. We gain very little if we include their records in group averages and their inclusion drastically lowers the sensitivity of group comparisons. In practice there may be some difficulty in deciding which individuals are so aberrant that they should be excluded. However, the situation is sometimes sufficiently obvious that there need be little doubt which course should be taken.

The validity of these arguments depends in part on analogies from the work of Dobzhansky and his colleagues on various species of *Drosophila*. While we cannot be sure how far some of these analogies are justified, there is no reason to suppose that the theoretical findings of population genetics, which appear to be substantially verified by research on both animals and plants, cannot be applied to similar problems in livestock and human genetics. The discussion has indicated the need for knowledge of biological quantities such as mutation rates, heterozygote fitness and number of loci. The fact that, even in Drosophila, estimates of these still lack the precision which might be desired, should not discourage us from recognising the need for such information, and from collecting and reporting the facts which may lead to increased accuracy in evaluating and defining the problems.

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Since writing this paper the author has read one by H. J. Muller (1950), *Amer. J. Human Genetics* 2: 111-176, *which discusses the problem of mutations with respect to human populations. Muller's conclusions are generally similar to those given above.*

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THOUGHTS ON THE TECHNOLOGY OF WOOL PRODUCTION

By P. R. McMAHON

Many people do not properly understand the term "technology", even in New South Wales, which has a University of Technology. Some tend automatically to associate "technology" with machines and with secondary industry. Technology, however, is defined by Fowler as "the science of the industrial arts" and elsewhere as "the application of science to industry", so that wool technology must include both the application of science to the wool textile industry and the application of science to wool growing. The technology of wool production includes the science of sheep breeding, feeding and management, and of all those things which appertain to the rich financial harvest which Australia derives from the sheep industry.

The Future of Wool Production in Australia

Perhaps the thought nearest to our minds is whether there will continue to be a technology of wool production, in other words, whether there is a future for the wool producer. There are many people, especially from the United States, who express gloomy forebodings as to the future of the wool industry because of the spectacular success which has been achieved by chemists in the preparation of the newer man-made fibres.

These people would stampede us into the idea that a small number of operatives could build a small factory and instal in it a simple machine capable of producing millions of pounds of beautiful, fine clean fibre, softer and more resilient than wool, from raw materials costing next to nothing. This, of course, is far from the truth. Quite apart from the very large amount of capital which must be expended in developing a new fibre to the commercial stage, the actual production plant is itself expensive. In the case of Terylene, for example, an expenditure of thirty million dollars was necessary to construct a plant which would turn out eleven million lbs. of fibre annually. The raw materials for the newer fibres cost anything from 15 to 40 pence per lb. and the final product sells at the present time for upwards of 140 pence per lb. While there is no doubt whatever that economies can and will be achieved, it is questionable whether a fibre which could compete with wool on a quality basis will be produced in the foreseeable future at much less than 100 pence per lb.

Although the newer synthetic fibres are excellent products they cannot be produced for next to nothing and in the long run it will be cost of production which determines whether a really good fibre such as wool will continue to find a market, and, again, with emphasis, we have to stress that wool is a good fibre. It is very elastic, has an excellent elastic recovery or resilience, good strength and resistance to fire, while it felts and takes dyes readily. It is available in a multitude of types at prices to suit all pockets and there already exists an enormous fund of knowledge about its utilization. There are millions of people who would either use some wool or more wool, if only they could afford it. It may be

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argued, therefore, that there will always be a market for wool and that if the price should fall this market will expand.

Again, it is interesting to compare the capital investment for manufacturing artificial fibre which, we have seen, is nearly 30/- per lb. of annual production, with land valuers' estimates of the money required to buy a living area for one sheep. An animal growing 6 to 7 lbs. of clean scoured wool requires, even at present prices, only £10 worth of capital in land, very much the same as the expenditure for a man-made fibre, but with the important difference that whereas a factory will depreciate in value the land, under proper husbandry conditions, will improve.

Last year, the Rural Bank of New South Wales investigated the cost of producing wool in this State and after allowing the owner a living wage and allowing for capital charges on the present value of the land, it was found that the average cost of producing wool was about 50 pence per lb. Now, we all know that the corresponding average price per pound for wool sold at auction last year was 82 pence per lb. and this leaves quite a comfortable margin for wool prices to fall before the sheep becomes a back number.

The position of the sheep as a wool producer is even stronger than these figures would suggest because there is no doubt whatever that if wool prices were to fall many of the costs of wool production would fall as well. While we do not wish to stress the argument too far, attention is drawn to the fact that wool producers during the war were happy enough to sell their clip at an average price of 15.3531 pence per lb. Australian.

It seems clear, therefore, that from the point of view of continuity, the wool producer in Australia is in a very strong position. Indeed, it is true that there may be changes in emphasis and it may be that some men now running one type of sheep may change to another, but it is unlikely that land suitable only for sheep raising will become a barren waste, or that persons trained in the wool industry will find themselves without a job.

The position is much less satisfactory, however, if looked at not from the point of the wool grower, but from the point of view of the Commonwealth as a whole. We all know that Australia rides on the sheep's back.

"I thanke God and ever shall,
It is the Sheepe hath paid for all,"

is as true now in Australia as it was in England in the 17th century. Last year the export of wool brought £400,000,000 into Australia, nearly half of our total export income. There are few people who did not suffer some inconvenience when wool prices fell suddenly in March of 1951 and import restrictions and economy measures were applied by the Commonwealth Government. There is, too, a very close correlation between the total income from our wool clip and the number of persons in gainful employment in Australia. Finally, a substantial part of our wool goes to dollar countries and so Australia's wool becomes important to the whole British Commonwealth as a means of providing purchasing power in the United States, Canada and South America.

Coming back to Australia, we have seen that there is a difference of approximately 30 pence between what it costs to produce wool and what the grower receives for it. If we assume that New South Wales' costs of production are similar to those in other States, we have a total profit of approximately £125,000,000, which is spread throughout the community by the purchasing power of sheep men, by investment of their savings, and through Government spending of the substantial taxation which they pay. Any reduction in this surplus

brought about by lower wool prices becomes of importance to the whole community. Similarly, and this is a point which is not often made, any gain in efficiency, any lowering in cost of production, is almost as much the concern of the man in the street as the cost of his transport or the price of his beer.

Technology and Wool Production

The application of science to wool production—the technology of wool production—is a vital interest of every man and woman in Australia and it is worthwhile spending a little time tracing the development of the sheep industry in terms of its technology. Here we can recognise three broad phases, an early phase with little technology extending from the middle of the 19th century, to the end of the great depression of the early 1930's. A second period with the development of technology—exploitation of the potentialities of science for the benefit of the industry by research—from 1930 until some unknown period in the relatively near future, and finally, the phase still to come in which science plays a major part in the planning and operation of the wool production enterprise.

In the early history of the industry we have a period when land was plentiful, when there were few difficulties to be overcome, save those capable of solution by commonsense methods, hard work and a certain amount of practical "know how". During this period there was little change in husbandry methods save those brought about by developments in other industries, in transport, and a limited amount of mechanisation. Wool production, nevertheless, rose, fleece weights increased with changes in type of sheep, and although quality in the sense of fibre fineness was lowered, this was more than offset by an improvement in length and style brought about solely by hit and miss breeding. During this period, too, the number of sheep increased as more and more land was brought into production.

It is appropriate to compare the situation in New Zealand where a smaller area of land available brought the non-technological phase to a close at the end of World War I. Here, because the pattern is further advanced, it is more clear. Up till 1920 production and increase in occupied area climbed more or less together, but about the end of World War I it became obvious that little more good land was available and that new methods based on the scientific study of Agriculture—the development of a technology—were necessary. About this period the extension teams and facilities of the Department of Agriculture were built up, the Department of Scientific and Industrial Research came into being and a new Agricultural College of the University of New Zealand was created. New Zealand has built up a team of extension workers which on the plant side nearly equals in number their corresponding colleagues covering the whole Commonwealth of Australia with an occupied area at least 15 times as large. Almost without exception these men are University graduates and through research, education and extension, agricultural and pastoral production have been almost doubled in the Dominion with no substantial change in the area of occupied land. To give a specific example it is quite common on good sheep country in New Zealand to find 8, 9 and 10 sheep to the acre run all the year round. In this process the man on the land has become more and more dependent on the scientifically trained technologist, on the soil surveyor for his basic knowledge, on the agricultural chemist who produces superphosphate, on the plant breeder for improved strains of pure breeding certified seeds, as well as on the herd improvement officers, on dairy technologists, on veterinary services, and, more recently, sheep and wool improvement officers.

This, then, would seem to be the pattern for Australia's second phase to follow the development of a technology, the

application of science to the sheep industry.

Although some work was commenced in the 1930's full emphasis was not given to science until the end of World War II. At this time there was a large accumulation of stored wool amounting to nearly eleven million bales, equal to one full season's world production and the development of cheap artificial fibres, which were believed to be a threat to wool's position, had reached a stage, especially in the Axis countries, where total production exceeded the available supplies of clean wool. To place the wool industry in a sound position to meet the future, the Commonwealth Government passed the Wool Use Promotion Act in 1945, and the Wool Industry Fund Act in 1946, reinforcing the Wool Publicity and Research Act 1936, and making very substantial sums of money available both for wool use promotion and for research into wool production and wool textiles. In 1945-46, for example, the expenditure on sheep and wool studies amounted to £85,000 whereas today the figure exceeds half a million pounds, quite apart from wool processing research.

The Returns from Technology

It is quite clear that with such large resources devoted to the technology of wool production, substantial gains will be made and already we can point to such major developments as the destruction of rabbits by myxomatosis, which has been estimated to result in an increase of up to 72 million pounds of wool in the 1952-53 clip alone. At 7/- per lb. this means over £25,000,000 more money for Australia. Another equally spectacular return from scientific study stems from the work on the sheep blow-fly. During the last war, losses due to this pest were estimated to cost the industry three and a half million pounds annually, corresponding perhaps to fifteen million pounds annually today if science had not developed a simple operation which renders sheep very much less attractive to the fly. How much the sheep industry already owes to pasture and soil investigations cannot be estimated, but it is quite sure that only a beach-head has been established in this sphere of influence. Closely related is the discovery that addition of compounds containing the trace elements copper, cobalt and zinc at the rate of 7 lbs. to the acre or less, together with superphosphate, enables land which was previously valueless to carry 1½ to 2 sheep to the acre. By the application of science, sheep diseases, notedly the very important Black disease, have been brought under control and a scientific study of drought feeding shows that it is more profitable and humane to feed mobs of sheep which are on a sub-maintenance diet once per week than to give the same amount of food as a daily ration.

Very many different groups of workers are contributing to this major research programme. Work at the School of Wool Technology in N.S.W. involves a study of the ecology of wool production, that is, the suitability of different types of wool for different types of environment and some contribution has been made towards a better understanding of the factors affecting the differential utility of various wool types. Briefly, it is found that under conditions where sheep get sufficient to eat to grow a heavy fleece of 11 to 12 lbs. of greasy wool, strong wool types (60's) of Merino cut 3½ lbs. more per head than fine wool types (74's) running in the same flock. On the other hand with poor native pastures running sheep which clip only 5 to 6 lbs. of wool, there is no loss of weight with even the superfine types (80's). Improved pastures, efficiently stocked with sheep clipping 9 to 11 lbs. per head show 1 to 1½ lbs. difference in favour of stronger types and this just makes up for the lower price per lb. of such wools. Under good conditions (heavy fleeces) it thus becomes more profitable to select for

strong wool types whereas fine and superfine wools can only be expected to give their most economical return where feed is relatively scarce. Improved pasture tends to change the situation from one where it pays to grow fine wool to one where fine wool and the stronger types both give much the same return per head. We do not find anything inconsistent between improved pastures and fine wool and we are convinced that more fine wool could and would be grown if the wool trade were to pay a greater premium for it to make up for the lower clip per head or, in some cases, for the higher mutton value of the sort of sheep which grow the stronger types of wool.

Research workers attached to the School are now setting out to use the detailed results of sheep breeding research to assist individual flock masters with their selection and culling programmes, replacing the hit and miss judgments of the past with a planned attack in which hand and eye appraisement will become secondary to objective measures of the important features such as fleece weight, yield and density of fibre.

The Role of the School of Wool Technology in N.S.W.

It is clear that we are now well advanced in the second phase, the development of a technological approach in wool production. It is equally clear that much remains to be done and the part which the School of Wool Technology will play in the future is beginning to emerge. Technology obviously depends on research workers, teachers and extension workers and so far as the sheep industry is concerned there has been no institution in Australia with courses specifically designed to fill these needs. The sheep industry has been served by graduates drawn from University courses in pure Science, Engineering, Agriculture and Veterinary Science, but more often their training has been at Diploma and Certificate level in Agricultural and Technical Colleges without matriculation standard of entry. In far too many cases senior workers have had no opportunity for tertiary education and their knowledge, usually highly specialised, comes from long practical experience and from personal contacts in the industry. The course aims to inculcate a scientific outlook and a habit of exact and logical thought, and at the same time to provide graduates who will be good practical sheep and wool men, capable of handling wool and recognising its technical characteristics. One broad aim of the course is to link producers, buyers and users of wool, while by association with lecturers and teachers who are engaged in research, both curiosity and interest are provoked so that students will themselves spend effort in contributing to the advance of knowledge and efficiency.

While the course aims to introduce students to the fascination of research, one must realise that not all graduates will find vocations in this sphere and stress is laid on the importance of spreading new knowledge through the industry and providing instruction in extension techniques.

In a final analysis, the Wool Technology Degree Course is a modified course of agriculture with the emphasis on wool, the sheep and its husbandry. In the first year, students attend lectures in science subjects which give them a background for subsequent studies in physiology and bio-chemistry. In the second and third years, practical knowledge in the handling of wool and the factors affecting the efficiency of the sheep industry is supported by the courses in economics, statistics and agronomy and in the final year the vocational knowledge of the sheep industry is extended by specialist studies in wool science, genetics, nutrition and farm management and courses in other farm livestock and the special agronomy of the pastoral industry.

Graduates of this course will be the wool technologists of the future. There are good grounds for believing that not only is there a future for the sheep industry and those who serve it, but that the development of a technological approach in the last 20 years has already been more than justified by results. The future holds equal problems. Increased burr and seed content, for example, and the occurrence of tender wool are problems which today look no nearer solution than did the rabbit or the blow-fly problems 15 years ago, and there are many other problems associated with the pastoral industry which will be solved by science and applied in practice in the future.

One last thought, a 1% gain in wool production at present prices means £4,000,000 to Australia—in this game the odds are high, but they favour the player.

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SOME PIONEERS OF SOIL INVESTIGATIONS IN AUSTRALIA

By G. BLACKBURN

Much of the earlier work on Australian soils is not well known because of publication only in annual reports of government departments, various agricultural journals, reports of royal commissions and only rarely in books which are hardly remembered today.

This account does not attempt to deal with all the pioneers of soil investigations in Australia, but the purpose is to draw attention to the valuable work done early this century and its importance in starting certain trends of work that are still pursued.

Leeper (1948) refers to the book of Howell (1910) "Soil Problems in Wheatgrowing", apparently the first Australian book on soils. F. J. Howell was Victorian Chemist for Agriculture from 1899 until 1905, and in 1902 advocated a complete chemical soil survey of Victoria and a soil map to give facts of practical value. His book contains analyses of various Victorian soils, both of surface and of subsoils, and these are still of value in demonstrating the general fertility levels in that State. The analyses are mainly for nitrogen, phosphorus, lime and mechanical composition. The book is in two parts: firstly, the chemical considerations, and secondly, the physical considerations. Despite the many shortcomings which the reader of today can find, the treatment is attractive and positive. Howell regarded the principal objective for wheatgrowing soils as an actual increase in soil moisture supplies or such alteration as would render these supplies more completely available. Three considerations deserved the attention of Victorian wheatgrowers, namely:—

1. the maintenance of organic supplies of the soil;
2. the liming of heavy clay lands, and
3. deeper cultivation, such as subsoiling, in cases where a comparatively shallow surface soil and tenacious refractory subsoil impart poor absorptive powers and interfere with root development.

He pointed to the dangers of over-cultivation involved in bare fallowing and warned of the probable depletion of nitrogen reserves in northern Victorian soils under the current farming systems. The author is generous in evaluation of his contemporaries: he refers to his predecessor in the Victorian Government service, A. N. Pearson, as the "father of scientific manuring in Victoria", prefaces his book with praise for the textbooks of Hilgard, Hall and King, and acknowledges the soil analyses made by P. R. Scott, the succeeding Chemist for Agriculture.

It is not easy to determine the originality of the work of Howell, or the extent to which he set down the ideas then current in Victoria. But at any rate many of the topics dealt with in his book were investigated later in Victoria, especially by the Department of Agriculture. Howell did not foresee that the major way to improve soil fertility would be through the use of short-term pastures in rotation with cropping, but he strove for the same object. The ameliorative measures he advocated may yet become popular if

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cereal growing is carried into the higher rainfall areas again.

The soil improvement approach stressed by Howell was also followed by P. Rankin Scott. During his tenure many soil analyses were made in Victoria and published in the Victorian Journal of Agriculture. He also published several papers in the same Journal jointly with either J. W. Paterson or H. A. Mullett, the present Victorian Director of Agriculture. Practically all of these dealt with experimental work on Victorian soils, covering the subjects of nitrification, the use of phosphates, liming, and the use of gypsum in soil amelioration. The last subject was dealt with in the paper with Mullett, published in 1923. This paper is noteworthy also for what is apparently the first modern soil profile description in Australia.

J. W. Paterson, formerly Professor of Chemistry in the West of Scotland Agricultural College, worked as experimentalist in the Victorian Department of Agriculture for a few years before becoming the first Professor of Agriculture in the University of Western Australia in 1914. In the three years, 1912-1914, he published 11 scientific papers, many of them jointly with P. R. Scott, in Victoria. In 1916, the first edition of his Australian textbook, "Nature in Farming", was published for use in schools and colleges. The next and apparently last major publication was his report to the Royal Commission on the Mallee Belt and Esperance Lands (1917).

Paterson was particularly interested in soil problems and was the first important contender against soil salinity in southern Australia. Adopting the term of Hilgard, Paterson published a paper in the Victorian Journal of Agriculture in 1913 on soil alkali, with particular reference to Victoria. Soon after his appointment to the Chair in Western Australia he visited the Esperance district and gained an appreciation of the problems which later involved an investigation by a Royal Commission. His report, nearly 30 pages, based on soil and water analyses and inspections of the area convinced him that settlement of about 2,500 square miles along the railway 80 miles inland from Esperance would be made difficult by soil salinity. He claimed that only a third of the area was useful for settlement, one-half being too salty for profitable farming. The Commission, however, was "not prepared to subscribe to such sweeping conclusions". This stand was taken after visiting mallee areas in Victoria and South Australia. In Victoria the late A. S. Kenyon stated to the Commission that soil analysis had so far only proved a hindrance to mallee settlement.

Experience confirmed the opinions of Dr. Paterson and this ensured that evidence of soil salinity was heeded in future plans for settlement in Western Australia. The investigations, about 1930 by Teakle, of soil salinity in the 3,500 farms scheme to the west of the Esperance railway led to the abandonment of that scheme. Paterson's report in 1917 showed appreciation of the probable movement of soluble salts after clearing. His analyses of waters include those from rainwater tanks and supported his earlier claim of 1913 that cyclic salt was an important source of salts in soils. This demonstration actually predates the better-known rainwater analyses given by R. L. Jack, in 1921, for South Australian localities.

An examination of the publications of J. W. Paterson will show that he pioneered many lines of investigation that are still pursued in Australia, including soil nitrification, the role of fallowing, the water requirements of cereal crops and soil salinity in relation to cereal culture.

The purpose of this article has been to draw attention to some of the valuable work done by pioneer soil investigators in Australia. Other men, including Guthrie, Brünnich and Jensen undertook

soil studies in New South Wales and Queensland, which in character and quantity are as significant as those described above. Both Guthrie and Brünnich carried out many soil analyses in New South Wales and Queensland respectively. H. I. Jensen, author of "The Soils of New South Wales" (1914), was almost certainly the first Australian soil surveyor. In South Australia the work of Professor Lowrie is known in connection with the introduction of superphosphate in wheatgrowing. It is not so well known that South Australians of German origin, Otto Tepper and H. E. R. W. Krichauff, gave early attention to soils: the former in 1879 as the author of a scientific paper on "Bay of Biscay" soils, and the latter as the translator and reporter of investigations abroad, especially those in Germany. Probably the first account in Australia of the soil alkali work of Hilgard was given by Krichauff in 1899.

A feature of the early soil work in Australia was its close association with practical problems of agriculture. The advantages of field experiments dealing with the application of fertilizers were appreciated first. Soil analyses and soil surveys were pioneered in New South Wales but experience in Western Australia first won for them a valued place in agricultural development. Field experiments dealing with soil mosture and nitrification were begun in Victoria. It can be seen that these early regional patterns in soil investigations continued to be influential for many years afterwards.

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SOME APPROACHES TO THE MEASUREMENT OF COSTS OF AND RETURNS FROM SOIL CONSERVATION

By I. MOLNAR

Soil conservation in its broad sense means retention of the soil and the maintenance of soil fertility through sound farming practices. In a more restricted sense, however, soil conservation means only the rehabilitation of land already eroded. Either form of soil conservation may be carried out on the whole farm or only on portion of it. Usually, however, maintenance or improvement of soil fertility applies to whole farms, while the rehabilitation of land already eroded is confined to paddocks only.

While a study of the economics of soil conservation in its broad sense can be made on a whole farm, soil conservation in its narrow sense can usually be studied in paddocks only. When the study is confined to a paddock it is assumed that most items of the total farm returns and expenses will remain unaffected by the rehabilitation of a relatively small section of the farm. Only returns and expenses definitely attributable to rehabilitation, therefore, are taken into account in the economics of the venture.

In this paper, an outline is given of some approaches to the investigation of the economics of soil conservation.

The Determination of Costs

Pasture Improvement without Mechanical Works

Whether or not a rehabilitation programme will include mechanical works will depend on the degree of erosion present. In Victoria, for instance, sheet erosion (with or without gullies) is fairly prevalent in areas which have a steep to undulating topography and a sparse native grass cover accompanied by stumps, logs and rocks. If the sheet erosion is not advanced, broadcasting of subterranean clover and superphosphate, together with drastic reduction of stocking during pasture establishment, will bring about adequate protection on such land.

To arrive at the true cost of the operation per acre on land of this type, however—even if depreciation on plant and equipment is ignored—is fairly difficult, because of the paucity of work records. Also, the collection of costing data is retarded, because sections of paddocks inaccessible to topdressing implements need also to be measured. Cost figures are useless if the area to which they refer is not known with reasonable accuracy. Even with well-defined areas many examples are required to determine the approximate costs of a given operation because operational skill, equipment and the condition of the ground at the time of an operation can vary considerably.

Mechanical Works

With advanced erosion present rehabilitation usually involves mechanical works in addition to conventional agricultural measures.

(a) *Works confined to small areas.* The cost of mechanical works confined to small areas, such as grass chutes or concrete drop structures (both used in the stabilization of gully heads) varies greatly from location to location. Similarly, the cost of preparing grassed

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waterways, used for the disposal of water from graded contour banks (or "terraces"), or the preparing of a water disposal area for diversion banks, will be greatly affected by local topography. The determination of the actual cost involved in these types of work seldom provides any difficulty and is usually a fraction only of the total costs of a soil conservation programme.

(b) *Works over broad areas or long distances.* Contour furrows and contour banks are the most frequent earth works constructed over broad areas. They are used for the reduction of water run-off, while diversion banks are often built over considerable distances for intercepting water run-off and disposing of it in safe places. The determination of costs of these works under different conditions can provide some difficulties.

Since contour furrows are usually ploughed under fairly rough conditions the costing difficulties connected with them are similar to those mentioned previously in connection with pasture improvement. In addition, the cost of contour furrows will be affected by their aggregate length per acre, which in turn will be governed by the spacing required between the furrows on a given slope. The steeper the slope the closer the spacing between the furrows, and the greater the aggregate length of contour furrows per acre. The slope of the contour furrowed paddock is, however, seldom uniform and consequently the various areas of different slope categories have to be determined before a cost per acre figure can have any useful meaning. Since, under field conditions, it is impracticable to measure the time required and the fuel used for contour-furrowing of each of the areas of different slopes, the conversion of a contour furrowed area of various slope categories into an area of a single slope can be done only if the length of the furrows on different slopes has been determined.

If such measurements were available the costs of contour-furrowing based on various slopes would enable the calculation of conversion factors for the computation of the cost of the same work on another slope, provided that conditions of work remained similar. It is not practicable, however, to carry out these measurements under field conditions without some mechanical recording device which is capable of withstanding rough conditions, and which does not interfere with the operator's work.

The cost of contour furrows is expressed per acre and on a steep slope it may be considered that the surface area will differ considerably from the true projected area on a horizontal plane surface, and that the measurement of the surface area would need to be converted to the plane area for accurate comparisons with less steeply sloping country. However, even for land with a slope of 30 per cent., which is approximately the upper limit which can be furrowed, the discrepancy of the surface and plane areas is only about 5 per cent. and is, therefore, not worth consideration.

The cost of contour banks is usually expressed per acre, though their length may vary to some extent according to the cross slope of the paddock. Since contour banks are normally not constructed on slopes which exceed 10 per cent., the variation in length per acre arising from differences in spacing is considerably less than in the case of contour furrows. The most important variation for contour banks is the width. The wider the bank, the more implement "rounds" are required for its construction. Consequently, the number of rounds required for the construction of a contour bank of a given length and width could make possible the computation of its *approximate* equivalent of a different width, thus facilitating calculation of costs.

The cost of diversion banks is always expressed per unit length because their length varies greatly with the locality.

The costs of diversion banks can be most conveniently converted into the costs for another diversion bank of different dimensions on the basis of the quantity of earth used in the construction of each one, provided both banks can be constructed by the same method (i.e., if both are on land of the same cross slope category).

The Determination of Returns

Changes in rotation often form part of a soil conservation programme for cultivated land. Since the evaluation of the effect of rotation on returns is impracticable, except under experimental conditions, problems associated with grazing land only will be considered.

Actual Production and Rates of Stocking

Under controlled experimental conditions it is practicable to measure actual production, as distinct from rates of stocking, for the determination of returns from soil conservation practices in a paddock. Under farming conditions, however, stocking rates have to be used as a measure of production. Rates of stocking, however, do not necessarily reflect actual production, hence they need to be substantiated by some measurement of ground cover.

Though the measurement of pasture yield, in addition to ground cover, would be desirable, this appears to be impracticable because of the great amount of labour involved when paddocks are large. Even the determination of ground cover is a formidable task. It has to be remembered that water erosion is generally, though not always, associated with inadequate subdivision of paddocks, hence the size of eroded paddocks is often large.

One method used for the determination of returns compares the rates of stocking before and after the introduction of soil conservation practices. The other compares the yearly stocking rates in a rehabilitated paddock with those in a corresponding eroded one.

"Before and After" Type of Comparisons

A paddock which has its own permanent water supply and which is not grazed in conjunction with any other paddock is selected, and records are kept of the movement of stock "on" and "off" this paddock. These records make possible the computation of the annual stocking rates. Because of differences in seasonal conditions it would be impracticable, however, to estimate the annual rate of change arising from conservation practices.

Soil Conservation versus Erosion

Under this method two paddocks (not necessarily of the same size) comparable regarding their past history, topography, soils, aspect and type of erosion are selected on a given holding. To one paddock conservation works and measures are applied but not to the other, and each one is grazed in approximately the same part of the year, though not necessarily with the same number of stock. The difference in annual rates of stocking can be computed for any one year.

Although this method is greatly superior to the "before and after" method, it is much more difficult to carry it out under normal farming conditions. First, the selection of such comparable paddocks is seldom possible, and, second, even if the farmer agrees to the simultaneous grazing of the two paddocks, it is unlikely that he will be willing to leave one paddock in its eroded state on seeing the general improvement in the reclaimed one.

Soil Conservation on a Farm Basis

If farm records are available over an adequate number of years the investigation of the economics of soil conservation on whole farms provides less difficulty than if the investigation is restricted to paddocks. Although the dissection of costs for each of the works and measures of the soil conservation programme is often practicable, the returns cannot be

accurately dissected except under experimental conditions.

The methods used for the determination of returns from rehabilitated paddocks can be applied to the investigation of the economics of soil conservation on whole farms. These are "before and after" type of comparisons and soil conservation versus non-conservation.

"Before and After" Type of Comparisons

This method compares the returns of the farm before and after the change in farming practices. It has two major shortcomings. First, seasonal conditions as well as rabbit populations can vary considerably over both periods and the returns can not be adjusted for such variations. Second, differences in the amount of work performed during each of the two periods can be assessed only where detailed work records have been kept for both periods.

Without detailed work records this method is of limited value because, unlike U.S.A. and Canada, there is, in Australia, surprisingly little data regarding the time requirements of farm operations under various conditions. It would be most likely that a farmer who is changing his farm management practices would work more hours per year than before the management change. If the monetary value of the difference in the amount of work performed during the two periods is not taken into account the profitability of the changes in management cannot be determined.

Soil Conservation versus Non-conservation

Farms are selected on which soil conservation farming is practised. These farms are classified according to land classes and total acreage. In the vicinity of such farms other farms which do not follow conservation farming practices are also classified according to land classes and size. For each "conservation farm" a "non-conservation farm" of similar size and of similar land class distribution is then selected for comparison. Incomes of such paired farms are then determined.

This approach can be criticized on the grounds that in comparing two farms, the investigator is actually comparing the managerial ability of the two farmers concerned. Therefore, differences in income are not necessarily attributable to different farming practices.

These difficulties were overcome in Illinois by Sauer (1947, and personal communication) who selected pairs of farms of comparable size and land class. In each pair one farm only had conservation plans drawn up by the Soil Conservation Service and most of the plans had been implemented. "Merit points" were then allotted separately for management and for conservation practices. Though management was only measured by personal judgment, soil conservation practices were assessed by applied conservation measures as percentage of the programme considered necessary. The economic analysis was then carried out with special reference to conservation merit points.

Conclusion

The collection of adequate cost data is largely a matter of available personnel. The determination of returns from rehabilitated paddocks or from "planned farms" is only practicable if appropriate records over several years have been collected, while for economic farm surveys soil maps and up-to-date erosion maps are essential. These are the prerequisites before the gains by the individual from soil conservation can be determined under various conditions.

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ECONOMICS OF THE GUARANTEED PRICE FOR WHEAT

By M. HODAN

Introduction

The subject of this paper is the guaranteed price under the Wheat Industry Stabilisation Act of 1948. The provision of the guaranteed price is interesting from two points of view. Firstly, the guaranteed price is equal to the domestic price of wheat for human consumption. Secondly, "where the average price per bushel obtained by the Board for wheat of a season exported by the Board is less than the guaranteed price, the net proceeds from the disposal of wheat of that season by the Board shall be deemed to be increased by an amount ascertained by multiplying the amount of the difference between that average price and the guaranteed price by a number equal to the number of bushels of wheat of the season exported by the Board, or by one hundred million, whichever is the less." (Commonwealth Act No. 48 of 1948.) The guaranteed price is a price in relation to sales of F.A.Q. bulk wheat F.O.R. at the port of export, arrived at by reference to the unit wheat production cost. The movement in this cost is shown by means of an index compiled annually by the Bureau of Agricultural Economics. The data concerning this index are discussed at the meeting of the Wheat Index Committee which is attended by a representative of the Australian Agricultural Council and a representative of the Australian Wheatgrowers' Federation. The final result is then submitted to the Minister for Commerce and Agriculture.

What is Unit Cost?

The unit cost is an expression of cost in terms of some selected unit, e.g., of product. A prerequisite in the calculation of the unit cost is the selection of a cost period for which the costs will be analysed. Then the costs are classified as direct and indirect. Direct costs are those elements of cost which are easily, obviously and conveniently attributed to the selected unit. Indirect costs are those elements of cost which are apportioned according to some chosen arbitrary rules. Adding the direct and indirect unit costs, the total unit cost is obtained.

The unit cost has many uses in the management of an enterprise. The use that claims the attention of an economist is the price fixation. Full-cost pricing has confused many an economist who saw in it a new theory of price determination replacing the orthodox marginal theory. An advanced cost accountant would not pronounce such a heresy. "The fixing of selling prices is not merely a matter of adding the desired unit profit margin to the unit production cost." (Dohr, J. L., 1946). Especially demand and supply must be considered. Surprisingly enough it was just the fixation of the guaranteed price which caught the fancy of the "fathers" of the Wheat Industry Stabilisation Plan.

General astonishment is intensified if it is realised that the most intricate problems of costing arise in the wheat industry. Wheat is grown on mixed farms. Joint products, farming operations in which costs are applicable to several products, none of which is of sufficient rela-

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tive importance to be considered as a major product, are common. The production of a major, or more joint products is, as a rule, accompanied by the production of one, or more, minor products called by-products. Specialised wheat farmers are exceptions. In the survey conducted by the Wheat Cost of Production Committee of 1947, only one out of 635 typical farmers produced solely wheat. A typical farm may be producing wheat, oats and barley. At the same time it may be growing wool, raising fat lambs and selling sheep. Simultaneous production of eggs, poultry and pigs in smaller quantities is not unusual. This phenomenon becomes clearer if it is realised that the physical needs of suitable rotation techniques must not be neglected and that a typical farm is a family farm.

Australian Average Unit Wheat Production Cost

The technical difficulties confronting the computation of the unit wheat production cost of an individual farm are formidable. The task of computing the average unit production cost for Australia as a whole seems to be impossible. Yet the computation was undertaken. Table I shows the relevant figures for the selected years of 1947-48 and 1952-53.

The figures for the year 1947-48 were the basis of the wheat production cost index. They were calculated from the original data collected by the Wheat Cost of Production Committee of 1947 for the five-year period 1942-43 to 1946-47. Five thousand questionnaires were mailed to farmers selected at random throughout Australia. The number of questionnaires sent to each State was in proportion to the State's acreage. The response to the questionnaires was poor. Only 851 questionnaires were returned and of this total 216 questionnaires were rejected because they contained insufficient data. The remaining 635 questionnaires, which were analysed, represented approximately one per cent. of all wheatgrowers in Australia. Since the number of returns from large farms was too high a proportion when compared with the actual distribution of farms according to the acreage, an adjustment was made to correct this bias. Finally, the average distribution of gross unit cost was obtained from a sample of 538 farmers. From the total average gross unit cost, the average unit sideline income, which was calculated on the assumption that there was no profit on sidelines, was deducted. In this way the average net unit cost was obtained. In order to bring this net unit cost to the F.O.R. ports basis, a uniform allowance of 10*d.* per bushel for freight and handling charges was added. The result of this inquiry into costs was that the domestic price, which was in 1947 only 4*s.* 11*d.*, was raised to 6*s.* 3*d.*

The figures for 1947-48 were then adjusted annually.* Each item of the average gross unit cost was revised separately. Assuming that the relative movements in sideline costs and wheat costs were equal, and that returns from sidelines were sufficient to absorb increases in sideline costs, the unit sideline income was subtracted from the adjusted average total gross unit cost. Thus the adjusted average net unit cost was obtained. The unit charge for rail freight and handling, which was added as the last item, was based on a preliminary estimate.

It will be interesting to indicate the methods of revision of the most important cost items, namely:—

(1) The change in the cost of the three labour sub-items was measured by the movements of the Commonwealth Urban Basic Wage (six capitals).

(2) The movement in "interest paid by farmers on borrowed capital" was ascertained by means of a questionnaire mailed to a sample of wheatgrowers. The movement indicator for "interest on farmers' equity" was

*The adjustments included a re-survey in 1950. Unfortunately no complete report has been published.

TABLE I.

Australian wheat cost of production per bushel.

Item	Average Cost per bushel in pence			
	1947-48		1952-53	
1. Labour: (a) farmers'	22.80		48.37	
(b) harvest }	9.24		10.35	
(c) other }			9.82	
Total		32.04		68.54
2. Interest: (a) on borrowed capital	5.28		1.85	
(b) on farmers' equity	13.08		19.18	
Total		18.36		21.03
3. Fuel		12.48		21.88
4. Maintenance: (a) on machinery	5.23		9.70	
(b) on structures	2.81		8.32	
Total		8.04		18.02
5. Depreciation		7.58		10.12
6. Seed		5.16		8.54
7. Fertilizer		4.32		11.76
8. (a) Rates and Taxes	2.19		4.30	
(b) Insurance	1.53		2.46	
Total		3.72		6.76
9. Cartage		1.80		3.48
10. Rent		1.80		2.47
11. Cornsacks		1.50		3.74
12. Miscellaneous		2.16		3.94
Total gross farm cost per bushel		98.96		180.28
Less sideline income per bushel		33.96		61.89
Total net cost per bushel at sidings		65.00		118.39
Plus freight and handling charges		10.00		24.36
Total cost per bushel F.O.R. ports		75.00		142.75

Note: This Table is based on:—
(1) Bureau of Agricultural Economics (1952-53)—Wheat production cost review, and
(2) Bureau of Agricultural Economics (1949)—Quarterly Review Agric. Econ., Oct., p. 56.

the Commonwealth Long-Term Loan Rate.

(3) The cost of "fuel" was adjusted by means of a weighted sub-index based on the movement in prices of fuels and lubricants for six representative wheat belt towns in the main wheat producing States.

(4) The sub-item "maintenance of machinery" was varied in accordance with the movement shown by a sub-index of prices of representative spare parts for farm machinery supplied by leading manufacturers and distributors. The calculation of the sub-index used in the adjustment of "maintenance of structures" was made on prices supplied by the Prices Commissioner in New South Wales, Victoria, South Australia and Western Australia and by reputable distributors of imported materials.

(5) In the case of "depreciation" a constant rate of physical replacement of assets was assumed. The item was varied in proportion to the estimated movement in depreciation costs arising only from the higher cost of replacing plant and structures.

(6) The item "seed" was varied by the percentage increase in the net costs of production at sidings for the previous crop.

(7) The item "fertiliser" was varied in accordance with an index taking account of the prices of superphosphate in different States.

(8) To ascertain the movement in "rates and taxes", a mail questionnaire survey of grower correspondents was used. This survey covered local government taxes, pasture protection board taxes, water rates, land taxes and road taxes. In respect of "insurance", a weighted average figure for the Commonwealth was calculated. This index covered rates charged by insurance companies in New South Wales, Victoria, South Australia and Western Australia on crop, livestock, fire, motor vehicles and other items.

(9) The item "miscellaneous" was moved proportionately to the movement in all other farm costs. (Bureau of Agricultural Economics 1952-53.)

Economic Implications of Australian Unit Cost

Enough has been said to be able to notice that the Australian unit cost computed by the B.A.E. was based on certain assumptions. The first assumption to be considered was the yield assumption. Since the data were analysed for the period 1942-43 to 1946-47, an average yield of 11.3 bushels per acre was implied. But in 1947-48 the actual yield was 15.86 bushels per acre. Thus in 1947-48 the "actual" average unit cost was definitely lower than the calculated average unit cost. The same can be said about the subsequent crop-years. The yield is essentially unpredictable and the use of a five-year yield average was not very helpful. In respect of this paragraph it is recommended that, since the basic aim of the calculated unit production cost should be to ascertain the cost which can be guaranteed, another cost unit should be adopted. The use of the acre instead of the bushel would eliminate much arbitrariness. Also more attention to the individual wheat growing districts could be paid.

The second important assumption was concerned with the sideline income. As mentioned above, it was assumed that the relative movements in sideline costs and wheat costs were equal, and that returns from sidelines were sufficient to absorb increases in sideline cost. Since the item "sideline income" was approximately one-third of the gross cost, the implications of this assumption were of the utmost importance. It is reasonable to say that the relative movements in sideline costs and wheat costs were approximately equal. But to assume that returns from sidelines were sufficient to absorb increases in sideline cost was definitely wrong, because they were more than sufficient to do this. Table II illustrates the case. The fifth column clearly shows that the percentage increases in the prices received for wool, which may be considered to typify the sidelines, have been since 1948 mostly significantly greater than the percentage increases in the prices paid for all production and market expenditures. Consequently, there has been a significant profit on sidelines throughout the time. Even in the initial year of 1947-48 there was a profit on sidelines. To assume that there was no profit on sidelines was a bad assumption (see Kinsman, 1954, for an analysis of this problem).

The third important point to emphasize is that the cost used in any year was the "historical" cost, that is, the cost of wheat production in the previous season. Since during the period under consideration Australia experienced an inflation, it is clear that, *cet. par.*, the "actual" average unit cost tended to be higher than the calculated average unit cost. If the assumption of *cet. par.* in the previous sentence is omitted, and it is realised

TABLE II.

Comparison of prices paid for production and market expenditures with prices received for wool.

Period	(1) Index of Prices Paid for Prod. and Market Exp.	(2) Index of Prices Received for Wool	(3) Percentage change in (1)		(4) Percentage change in (2)		(5) (4)—(3)	
	Base: Average of 10 half-years ended June, 1950.		+	—	+	—	+	—
1948—June	101	112	0	0	0	0	0	0
Dec.	106	127	5		15		10	
1949—June	111	125	5			2		7
Dec.	117	145	6		20		14	
1950—June	126	191	9		46		37	
Dec.	142	336	16		245		229	
1951—June	167	418	25		182		157	
Dec.	193	211	26			207		233
1952—June	196	181	3			30		33
Dec.	199	215	3		34		31	
1953—March ..	196	230		3	15		18	
June	198	212	2			18		20
Sept.	200	217	2		5		3	

Based on: Saxon, E. A. (1954)—The measurement of movement in prices received and paid by primary producers. A.N.Z.A.A.S. 30th Meeting.

that the yield assumption tended to overestimate the calculated average unit cost, it is plausible that the final result obtained by the B.A.E. tended to approach the "actual" average unit cost.

The last important question is concerned with imputed costs. Imputed costs have the character of assumptions. They represented in 1947-48 43.93 per cent. of the average gross farm cost. It is not practicable to discuss the absolute magnitude of these items and only the problem whether they should have been included at all will be discussed.

"Farmer's labour" was the most controversial item. It represented, in 1947-48, 23.0 per cent. of the average gross farm cost. It consisted of an allowance for farmer's labour equivalent to the urban basic wage and a margin for management. It is clear that labour is an essential factor of production and that it should be included in the costs. The controversy applied only to the magnitude of the managerial allowance.

"Interest on farmer's equity" was the second largest item of the average gross farm cost, of which it represented, in 1947-48, 13.2 per cent. The inclusion of this item in the cost was justified since it was the return on farmer's capital. This conclusion can be supported by the argument that if there is a decline in farmer's indebtedness, there is an automatic and identical increase in equity, and that the interest which would be payable on the borrowed capital should be imputed on the equivalent increase in the farmer's capital.

"Depreciation" represented only 7.7 per cent. of the average gross farm cost. There is no doubt that its inclusion in the total cost was proper.

Guaranteed Price and Wheat Markets

Essentially there have been four markets dealing in Australian wheat:—

(1) the domestic market in wheat for human consumption;
(2) the domestic market in wheat for animal feed;
(3) the International Wheat Agreement market; and
(4) the "free" market in wheat.

The prices received in all these markets were pooled by the Australian Wheat Board, and the farmers received an average price. The assistance under the Wheat Stabilisation Plan was never needed because the average export price

TABLE III.

Prices received for Australian Wheat.

Pool No.	Pool Season	Advances Received per bush.	Guaranteed Price per bush.	Average I.W.A. Price (Maximum) per bush.	Average "Free" Export Price per bush.
		s. d.	s. d.	s. d.	s. d.
11	1947-48	14 3.700	6 3	—	19 4.7
12	1948-49	11 3.405	6 8	—	15 8.2
13	1949-50	13 0.062	7 1	15 3.2	18 6
14	1950-51	12 7.378	7 10	16 1	18 8
15	1951-52	14 2.936*	10 0	16 1	20 9.3
16	1952-53	13 — *	11 11	16 1	20 1

*Incomplete. Payments up to Jan. 1, 1954.

Based on: (1) Commonwealth Economic Committee: Grain Crops—1953;
(2) Bureau of Agricultural Economics: The Wheat Situation, Jan., 1954.

was all the time higher than the guaranteed price. The guaranteed price was effective only in respect of the domestic market. But here the price situation was complicated by subsidies and other regulations. In 1949-50 a subsidy of 5 pence per bushel of wheat for human consumption was paid to the Board by the Commonwealth Government. In 1951-52 a surcharge of 2*s.* per bushel over the guaranteed price of 10*s.* was authorised for sales of wheat used as stockfeed.* In the same year a bounty of 4*s.* 1*d.* per bushel on all sales for stockfeed up to 26 million bushels was guaranteed (Commonwealth Act No. 82 of 1951). After 1951-52 only wheat sold for human consumption was at the guaranteed price. The price of wheat sold as stockfeed was all the time significantly higher. Table III summarises the price situation in the relevant period.

It is interesting to analyse what were the economic implications of the price situation in Table III in relation to the above-mentioned four markets. The markets were listed in order of priority. The first two markets which had to be satisfied were the domestic markets. The surplus which was left over and above the quantity required by the domestic markets was available for exports. From the two export markets, the I.W.A. guaranteed market had to be supplied first. The "free" export market was of a marginal character. A glimpse at Table III suffices to reveal that the price was the lowest in the markets with highest priority and vice versa. The result of this situation was that the farmer could not help feeling that his interest was sacrificed. Firstly, since in absence of any regulations, the domestic price would have tended to gravitate toward the export prices, the farmer felt that he was subsidising the domestic consumption of wheat. Secondly, since the "free" export price was significantly higher than the I.W.A. maximum, the farmer felt his obligation under the I.W.A. as a burden. Essentially it was the domestic price and the I.W.A. maximum price which tended to keep the average price announced by the A.W.B. below the world "free" parity. The farmer reacted by restricting the acreage under wheat. Farming resources were switched to the production of other rural products, the price of which offered a better return. This tendency was intensified by the slow payment of advances by the A.W.B. and by the retention of high amounts in the Wheat Industry Stabilisation Fund. The important point is that farmers' policy of restricting the acreage under wheat was self-defeating. The less was produced, the lower tended to be the average price, because the less could be sold in the marginal "free" market overseas. In spite of the slowly in-

*This did not apply to Western Australia.

creasing guaranteed price, the above situation persisted. Only a series of good harvests saved the Australian wheat industry from the full impact of the depressing elements inherent in the Stabilisation Plan.

Conclusions

The above economic analysis should be a lesson for the future Australian wheat marketing policy. The average unit cost is based on certain assumptions. If these assumptions are unrealistic, the unit cost which is calculated on these assumptions is also unrealistic. Under certain circumstances, the imperfections due to these assumptions may tend to cancel out. But this is not to say that the unit cost of production is a good basis for the price fixation. Essentially, the price is determined by supply and demand. Assuming no authoritarian economic controls, any method which ignores these elementary economic forces is doomed to fail. The guaranteed price, based on the unit cost of production, introduces unnecessary complications in the wheat market. It could never stabilise the "wheat industry". A typical farm is a mixed farm. The income on such a farm is determined not only by prices received but also by quantities sold. Both wheat and sideline products have to be considered. The consideration of products retained on farms must not be neglected. The "wheat industry" cannot be stabilised in isolation. The stabilisation of farmers' income is an important problem. It deserves more "real" attention than it has received.

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THE INFLUENCE OF SULPHUR ON A NATURAL MEDICAGO PASTURE

By E. J. HILDER and K. SPENCER

Summary

The first recorded response in Australia of a natural pasture to sulphur applications is described. The increased growth occurred mainly in the medic component of the pasture. During the winter period the dry matter production of the medics was increased sixfold, 90 per cent. of the calculated maximum increase being produced by a dressing of gypsum equivalent to 20 lb. sulphur per acre.

Chemical analyses of the pasture samples showed increasing contents of sulphur, and protein and non-protein nitrogen, with each higher rate of sulphur application.

The very large responses obtained are thought to be due to the fact that the soil was in an undisturbed state when sulphur was applied.

Introduction

On a property on the northern foothills of the Liverpool Range near Willow Tree, New South Wales, general unthriftiness of weaners, and wool characters suggestive of copper deficiency, were observed by Dr. D. F. Stewart, of the C.S.I.R.O. McMaster Laboratory, Sydney. The authors examined the pastures for possible copper deficiency in October, 1951, but no specific symptoms due to low copper were seen.

However, the general appearance of the sown pastures suggested that there was a marked shortage of sulphur. Samples of both phalaris (*Phalaris tuberosa* L.) and burr medic (*Medicago denticulata* Willd.) were found to contain normal amounts of phosphorus but were low in sulphur content (0.08 and 0.13 per cent. respectively).

Soils of this region are derived from Tertiary basalts. Typical krasnozems are developed on the higher country while black earths are found on the lower slopes and flats. The elevation is about 1500 ft. above sea level and the annual rainfall is approximately 28 in., although greatly exceeded in 1949-1950.

White box (*Eucalyptus albens* Miq.) was the most common tree on the slopes with apple gum (*Angophora intermedia* D.C.) in the depressions.

The area of natural pasture selected carried similar proportions of legumes and non-legumes. Legumes consisted chiefly of woolly burr medic (*Medicago minima* L.), burr medic (*M. denticulata* Willd.), and button medic (*M. orbicularis* (L) Bartal.), with a little clustered clover (*Trifolium glomeratum* L.). The main annual grasses were *Vulpia bromoides* (L.), S. F. Gray, *Koeleria phleoides* (Vill.) Pers., and *Hordeum leporinum* Link, while the perennial grasses *Danthonia* spp. *Dichanthium sericeum* (R.Br.) A. Camus, *Chloris truncata* R. Br. and *Bothriochloa decipiens* (Hack.) C.E. Hubbard, were less evident.

The soil at the experimental site, which had never received fertilizer previously, was a silty clay loam of pH about 8.0 and showing black earth characteristics.

Experimental

Treatments consisted of varying rates of superphosphate (22 per cent. P_2O_5) and gypsum (agricultural grade), separately and in various combinations, to give seven treatments with sulphur equivalent to 0, 9.2, 15.3, 21.1, 21.6, 34.8 and 67.2 lb. per acre. The corresponding phosphorus (P) rates were 0, 8.1, 0,

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18.6, 10.4, 11.6, 11.6 lb. per acre respectively. There were four replications of a randomised block design. In addition a strip of copper sulphate at 10 lb. per acre crossed all treatments.

Fertilizers were applied to the undisturbed surface of the soil through a tyne drill on April 18, 1952, and the sward, which remained ungrazed, was sampled on August 12 for yield of dry matter and for chemical composition. Nitrogen fractions were estimated by the method of Anderson and Spencer (1950) and sulphur by the method of Steinbergs (1951).

Results

Conditions for growth were good during the whole period of the experiment, as adequate rains were received throughout. Six weeks after the applications were made, marked improvement in medic growth was observed wherever gypsum or superphosphate had been applied, but growth on the untreated plots remained poor and continued to be poor throughout the winter period. By the sixteenth week the dark green vigorous plants (12-18 in. high) on the fertilized plots contrasted strikingly with the pale green stunted plants (3 in. high) on the untreated plots.

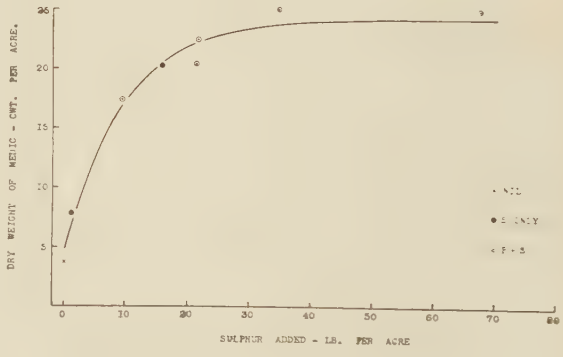
At sampling small woolly burr medic was the most prominent legume on the control plots, while burr and button medics were completely dominant on the fertilized plots, being greatest with higher rates of sulphur. Woolly medic apparently responded much less to fertilizer than the other medics.

Nodulation was also affected. Large branched and pinkish nodules were associated with plants receiving sulphur while the untreated plants bore small, scattered unbranched nodules with greenish pigmentation near the base of the nodule.

The dry matter yields of forage after 16 weeks are presented in Table I.

Yield figures show a very great increase in productivity in treatments 2-7 inclusive compared with the control (treatment 1) the figures also show that most of the increase is due to the medic constituent of the pasture. The percentage of legume in the pasture also increased because the grasses and weeds responded less markedly to fertilizer.

It is apparent from Table I that increase in yield is related to the rate of sulphur application. In Figure 1 the yield of medic is plotted against increasing sulphur levels and the Mitscherlich curve of best fit drawn. The calculated maximum is 24.3 cwt. per acre. Untreated plots yielded only 15 per cent. of this maximum while even as small a quantity of sulphur as 1.3 lb. per acre improved the productivity considerably. Five pounds per acre of sulphur produced 50 per cent. of the maximum yield and 20 lb. (equivalent to nearly 1 cwt. gypsum or to 2 cwt. superphosphate) gave 90 per cent.



$$Y = 24.31\left[1 - e^{-0.1041\,(x + 2.075)}\right]$$
χ^2 test, $P + 0.50$

Figure 1.
Effect of sulphur additions on yield of medic.

Both Table I and Figure 1 indicate that there was no response to phosphorus in superphosphate.

Analyses of the complete herbage for total sulphur and for total and protein nitrogen were made and the results are presented in Table II. Non-protein nitrogen was calculated by difference.

TABLE I.

Yields of Pasture Components with Increasing Rates of Sulphur Application.
(cwt. dry matter per acre.)

Treatments			Yield of Components				
No.	lb. equiv. per acre		Medic	Grass	Weed	Total	% Medic
	Sulphur	Phosphorus					
1	0	0	3.61	2.87	1.21	7.70	47
*	1.3	0	7.67	1.59	0.81	10.08	71
2	9.2	8.1	17.39	4.03	1.70	23.13	75
3	15.3	0	20.36	3.61	1.63	25.61	80
4	21.1	18.6	20.28	4.14	1.48	25.91	78
5	21.6	10.4	22.46	3.42	1.51	27.40	82
6	34.8	11.6	25.03	3.25	1.88	30.17	83
7	67.2	11.6	25.07	3.03	1.42	29.52	85
Min. diff. for sig. $P < 0.05$			3.87	n.s.	n.s.	3.92	

*Copper sulphate strip (see text).

TABLE II.

Chemical Composition of the Total Forage.
(as percentage of dry matter.)

Treatments			Percentage composition			
No.	lb. equiv. per acre		Sulphur	Nitrogen		
	Sulphur	Phosphorus		Non-protein	Protein	Total
1	0	0	0.17	0.88	2.76	3.64
*	1.3	0	—	—	—	—
2	9.2	8.1	0.22	1.27	3.31	4.58
3	15.3	0	0.28	1.63	3.31	4.94
4	21.1	18.6	0.27	1.53	3.21	4.74
5	21.6	10.4	0.27	1.57	3.27	4.84
6	34.8	11.6	0.32	1.62	3.28	4.90
7	67.2	11.6	0.38	1.79	3.35	5.14

*Copper sulphate strip not sampled for chemical analysis.

Total sulphur and total nitrogen contents of the herbage rise steadily with increasing levels of sulphur application. All of the increase in protein nitrogen takes place with the first 9 lb. of added sulphur but non-protein nitrogen rises slowly with increasing levels of applied sulphur. The nitrogen values generally are particularly high for plant material.

Discussion

The most outstanding feature of this experiment is the very large increase in production of a natural pasture with applied sulphur namely, a fourfold increase in total forage and a sixfold increase of medic alone. With one exception (Bledsoe and Blaser, 1947) the response obtained is greater than any published response sighted by the authors. An improvement of *medic* growth was obtained with sulphur fertilizing in California (Conrad, Hall and Chaugule 1947), but of a much lower order.

It is noteworthy that the characteristic symptoms of sulphur deficiency namely, a general yellowing of the leaves, were not evident on the control plots under these conditions of extreme deficiency. But when a small quantity of sulphur was applied (as copper sulphate) the typical light yellow leaves became apparent. This suggests that with a severe shortage of sulphur, leaf colour may not be a reliable guide to the need for this nutrient.

Applied sulphur did not have the same effect on grass and weed growth that it had on the medic. Anderson and Spencer (1950) showed that non-legumes adequately supplied with nitrogen will respond to sulphur as generously as legumes and hence it appears that this soil was also low in available nitrogen. There was a slight response by grass at the lower rates of sulphate but legume competition became more restrictive with the higher rates.

Observations on botanical composition indicate that the medics vary in their response to sulphur. On the control plots woolly medic was quite abundant while the other medics were inconspicuous. With applications of sulphur at rates above 9 lb. per acre this situation was reversed; burr and button medics became the dominants while woolly medic was insignificant. The relative abundance and size of these medics may have some value for diagnostic purposes.

The gradual increase in percentage of non-protein nitrogen from treatment 2 to treatment 7 suggests that the plants continue to accumulate nitrogen in the form of simple compounds, while the protein nitrogen content soon reaches a maximum value and remains constant. Although the changes in sulphur and in protein nitrogen content of the dry matter are in line with those reported by Anderson and Spencer (1950) and Andrew, Kipps and Barford (1952), the non-protein nitrogen behaves differently. Instead of a marked decrease in non-protein nitrogen with the addition of sulphur, Table II shows a steady increase with increasing sulphur level. It is therefore suggested that in the published results of these other workers the higher non-protein nitrogen values quoted in their controls may have been influenced by the nitrogen released through the disturbance of the soil during potting.

In case the responses reported in this paper were due to calcium, either *per se* or as potassium released in cation exchange by calcium, a further small trial involving various cations was made, and showed no response. Sodium sulphate was equally effective as gypsum. Further, copper chloride did not improve the growth of medic species, hence the effect of copper sulphate may be attributed to its sulphur content.

Soils of the type used in this experiment are highly regarded agriculturally but under natural pasture they do not show to similar advantage. This difference may be largely due to increased

availability, through cultivation, of elements normally relatively poorly available in undisturbed soil. In this way sufficient nitrogen may be released from these potentially fertile soils for a large crop and it is suggested that the same effect might occur with sulphur (Hilder, 1954). This seems likely because in attempting to demonstrate deficiency symptoms in plants growing in pots of this soil (Spencer, unpublished data) results were disappointing. Further evidence may be adduced from local farmers' reports of very slight or practically no response by cereal crops to superphosphate. Hence had the experiment been conducted on pasture sown on a well prepared seed bed instead of an undisturbed natural sward the effect of sulphur might have been greatly reduced.

There have been several previous reports (Andrew, Kipps and Barford 1952; McLachlan 1952; Anderson and Arnott 1953; Hilder 1954) of sulphur response on basaltic soils in eastern Australia and it would appear that the deficiency may be characteristic of soils derived from basalt on the Tablelands belt of New

Figure 3.
Single plants of burr medic photographed at the time of the yield sampling, August 12.

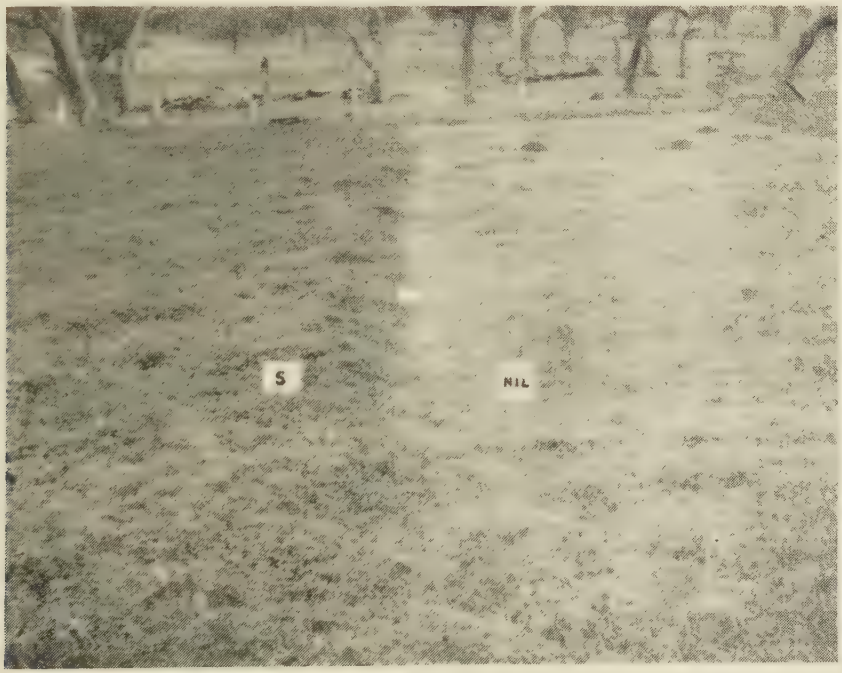


Figure 2.
General view of medic-dominant pasture showing untreated strip (right) and sulphur-treated strip (left).

South Wales. In this and similar instances the lack of response to phosphorus permits the replacement of superphosphate as a fertilizer with gypsum, a much less expensive source of sulphur.

Acknowledgments

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The chemical analyses were carried out by Mr. J. R. Freney and Mr. A. Steinbergs of this Division.

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A COMPARISON OF D.C.P.A., T.C.P.A., AND ARSENIC FOR KILLING EUCALYPT REGROWTH IN SUB-TROPICAL NATIVE PASTURES

By W. J. BISSET and N. H. SHAW

Summary

Experiments to assess the effectiveness of D.C.P.A. and T.C.P.A. as substitutes for arsenic for killing eucalypt regrowth, mainly *Eucalyptus tereticornis*, are described. The compounds were applied as water solutions and emulsions to frilled trees and to cut stumps.

Kills of 80 to 100 per cent. were obtained with arsenic. In many cases the phenoxyacetates were equally effective, but the results were not consistent, and they do not suggest any satisfactory explanation for this variability.

There was little difference between D.C.P.A. and T.C.P.A., or between different formulations of these compounds.

Transference of arsenic from treated to untreated trees was observed in *E. tessellaris* and this was shown to be via root fusions. This effect was not observed with the phenoxyacetates.

The role of poisoning in control of eucalypt regeneration is discussed.

Introduction

The development of *Eucalyptus* forest country as grazing land in eastern Australia has been achieved through killing the trees by ringbarking to encourage better growth of native grasses. In much of this country, particularly in Queensland, the eucalypts tend to regenerate with consequent depression of grass growth. This constitutes a major problem for the landholder and the position is aggravated by the tendency for the regeneration stand to be denser than the original. The density and speed of the regrowth appear to be broadly correlated with the general fertility levels of the soils—the poorer the soils the more vigorous is the regeneration, and in such cases, control treatment may have to be repeated every ten to fifteen years.

The only methods of control in general use are to wait until the trees are big enough to ringbark, or to poison the young trees with arsenic compounds. Neither method has been entirely satisfactory, since in both cases the treated trees are soon succeeded by another crop. Poisoning with arsenic has the additional disadvantage of requiring special precautions to ensure the safety of the operators and of grazing animals. Experiments were commenced in 1947 to assess the value of some of the chlorinated phenoxyacetate herbicides as substitutes for arsenic. These compounds, if effective, would have the advantage of being non-poisonous.

During the course of these investigations it was pointed out by Jacobs (1951) that when the trees of a eucalypt forest are killed, the way is opened up for the sudden growth of successors from hitherto inconspicuous lignotubers which had been kept in a state of suppression by the grown trees. Jacobs states that ". . . a succession of crops is likely unless all trees and lignotubers are done away with, or until pasture management reaches a point where a combination of good pasture and grazing keeps the shoots from the lignotubers in a state of continued suppression". From this observation it is clear that treatment of individual trees by ringbarking or poisoning offers no more than temporary control, and that fundamentally the control of eucalypt regeneration and the development of improved pastures are two aspects of the one problem. In view of this, tree-killing experiments were not continued after 1951, and attention was concentrated on

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TABLE I.

Percentage kill of E. tereticornis saplings treated with D.C.P.A., T.C.P.A. and arsenic at different times of the year (numbers treated shown in parentheses).

Treatments	Percentage kill													
	Frilled Trees							Stumps						
	May, 1948	July, 1948	Oct., 1948	Oct., 1949	Jan., 1950	Apr., 1950	July, 1950	May, 1948	July, 1948	Oct., 1948	Oct., 1949	Jan., 1950	Apr., 1950	July, 1950
Na D.C.P.A. 0. 5%	44 (9)	6 (16)	87 (31)	60 (20)	65 (20)	35 (20)	80 (20)	38 (13)	46 (13)	83 (31)	95 (20)	75 (20)	80 (20)	60 (20)
,, ,, ... 1. 0%	62 (16)	33 (18)	93 (30)	100 (20)	40 (20)	90 (20)	45 (20)	50 (8)	33 (6)	64 (29)	100 (20)	80 (20)	100 (20)	65 (20)
Ethyl D.C.P.A. 0. 5%	50 (12)	7 (15)	64 (14)	65 (20)			10 (20)	30 (10)	32 (19)	54 (13)	95 (20)			70 (20)
,, ,, ... 1. 0%	57 (14)	41 (17)	77 (13)	100 (20)			50 (20)	38 (13)	55 (9)	21 (14)	100 (20)			65 (20)
Amine D.C.P.A. 0. 5%						55 (20)							75 (20)	
,, ,, ... 1. 0%						80 (20)							90 (20)	
Na T.C.P.A. 0.58%				90 (20)	65 (20)						100 (20)	74 (19)		
,, ,, ... 1.16%				100 (20)	63 (19)						100 (19)	80 (20)		
Ethyl T.C.P.A. 0.58%				100 (20)			0 (20)				100 (19)			20 (20)
,, ,, ... 1.16%				90 (20)			30 (20)				100 (19)			25 (20)
Amine T.C.P.A. 0.58%						75 (20)	50 (20)						100 (20)	65 (20)
,, ,, ... 1.16%						95 (20)	80 (20)						90 (20)	75 (20)
As_2O_3 .. .. 6. 4%				85 (20)	60 (20)						85 (19)	90 (20)		
,, ... 8. 7%						42 (19)	70 (20)						55 (20)	100 (20)
,, ... 12. 8%				89 (18)	80 (20)						80 (19)	95 (20)		
,, ... 17. 4%						85 (20)	95 (20)						85 (20)	100 (20)
As_2O_5 .. .. 10. 0%				80 (20)		50 (20)	75 (20)				100 (19)		85 (20)	100 (20)
,, ... 20. 0%				90 (20)		90 (20)	80 (20)				100 (19)		85 (20)	100 (20)
Control	0 (12)	0 (14)	0 (15)	10 (20)	0 (20)	10 (20)	0 (19)	0 (9)	0 (10)	0 (15)	0 (16)	0 (20)	0 (20)	0 (20)

Note: 0.58% T.C.P.A. is equimolecular with 0.5% D.C.P.A., and 8.7% As_2O_3 is equivalent to 10% As_2O_5 in arsenic content.

developing more vigorous pastures. However, the information obtained up to the conclusion of the experiments suggests that in many cases phenoxyacetates could be used as a substitute for arsenic and as such seems worth placing on record.

Figure 1.
Lignotuber and roots of E. tessellaris showing fusion between roots from the same tree and from neighbouring trees. Points of fusion are indicated by crosses.

Experimental Methods

The experiments were located at "Rodd's Bay" near Gladstone, at "Ban-Ban" near Gayndah, and on a Shire Council Reserve near Gatton. The herbicides were applied as water solutions and emulsions in a manner similar to that used for arsenical tree-killers, except that a special apparatus was used to enable cutting and poisoning to be carried out in one operation (Bisset, 1952). The size of trees ranged from small bushes to saplings of 4 in. diameter. The larger saplings were frilled as near as possible to ground level and the fluid applied to frill cuts that overlapped, but were not necessarily joined. Smaller trees and bushes were chopped off and the fluid applied to the cut surface of the "stumps", and trees treated in this way are referred to throughout the paper as stumps. Sufficient fluid was applied to ensure thorough wetting of the cut surfaces and the average amount used was 1 fluid ounce per tree. The treatments were applied to randomised plots of trees within a fairly uniform stand. Trees showing excessive basal malformation (from fire or other causes) were excluded. In all cases control treatments, consisting of trees, which were frilled or chopped off but without application of herbicide, were included. Observations on the death of tops and the development of shoots from below the treatment cuts were made at 3-monthly intervals over a period of 12-15 months. This period was sufficient to allow an assessment of the full effects of any treatment. A tree was presumed to be killed if, after 12 months, the portion above the frill was completely dead and there were no live shoots from below the frill. Absence of live shoots was the criterion in the case of stumps. The trials were mainly restricted to *Eucalyptus tereticornis* Sm., but some tests were made on other species.

Experiments with E. Tereticornis

Following preliminary trials in 1947, seven experiments were carried out at "Rodd's Bay". The compounds tested were the sodium salts, ethyl esters, and triethanolamine salts of D.C.P.A. and T.C.P.A. (2,4-dichloro-, and 2,4,5-trichlorophenoxyacetic acid) and the trioxide and pentoxide of arsenic. Details are given in Table I.

The results obtained with the stronger solutions of arsenic were consistently good, but the weaker solutions sometimes gave poor results. In 10 out of 14 comparisons the percentage kill of stumps was slightly higher than that of trees, the overall averages being 90.0 per cent. and 77.2 per cent. respectively. There was little difference between the two oxides at equivalent strengths. Recovery of frilled trees treated with arsenic was by shoots from below the frill; in only two trees out of 277 treated did the top fail to die.

With the phenoxyacetates the results varied from very good to poor, and there was no consistent difference due to type of compound or time of application. In most cases the stronger solutions were better than the weaker. In general the

kill for stumps was slightly better than that for trees. Recovery of frilled trees treated with phenoxyacetates was both by development of shoots from below the frill, and by healing of the frill cuts. Healing of the frill cuts was very common in the control treatment.

Experiments with Other Species

Table II gives details of trials with *E. tessellaris* F. Muell. at Gatton and *E. populnea* F. Muell. at "Ban-Ban". Arsenic and T.C.P.A. were highly effective on both species, whilst D.C.P.A. was effective on *E. populnea* but not on *E. tessellaris*.

During the course of the experiments at Rodd's Bay small numbers of trees of *E. crebra* F. Muell., *E. dichromophloia* F. Muell., and *Casuarina luehmanni* R. T. Baker were treated with salts of D.C.P.A. with promising results.

Transfer of Arsenical Poison to Untreated Trees

In the experiment with *E. tessellaris* several untreated trees growing near others treated with arsenic developed arsenic-toxicity symptoms. Jacobs (1951) suggests that in such cases transference of arsenic from one tree to another has probably occurred as a result of root fusions and excavation showed that this was so. Many instances of fusion between roots from the same tree and from different trees were found (see Figure 1), and longitudinal dead strips in roots from untreated trees were found to be continuations from dead roots of treated trees. No case of transference from

TABLE II.

Percentage of kill of E. tessellaris and E. populnea saplings treated with D.C.P.A., T.C.P.A. and arsenic.

(Numbers treated shown in parentheses).

E. tessellaris			E. populnea		
Treatment	Percentage kill		Treatment	Percentage kill	
	Frilled Trees	Stumps		Frilled Trees	Stumps
November, 1949—			May, 1950—		
Amine D.C.P.A. 0.5%	30 (20)	60 (20)	Amine D.C.P.A. 1.0%	70 (29)	75 (19)
Amine D.C.P.A. 1.0%	30 (20)	55 (20)	Ethyl D.C.P.A. 1.0%	—	90 (34)
Amine T.C.P.A. 0.58%	100 (20)	100 (20)	Amine T.C.P.A. 1.16%	—	95 (34)
Amine T.C.P.A. 1.16%	100 (20)	100 (20)	As_2O_3 20.0%	—	100 (39)
As_2O_3 6.4%	100 (20)	90 (20)	Control	—	0 (23)
As_2O_3 12.8%	90 (20)	90 (20)			
			June, 1950—		
Control	0 (20)	0 (20)	Sodium D.C.P.A. 1.0%	100 (20)	100 (20)

treated to untreated trees was observed with the phenoxyacetate compounds.

Discussion

The experiments have shown that in some cases water solutions and emulsions of D.C.P.A. and T.C.P.A. applied to frilled trees and cut stumps of *E. tereticornis* were as effective as arsenic, giving kills of 90 to 100 per cent. Limited tests with other species also gave some good results. Treatments at different times of the year with the same phenoxyacetate compound varied in their effectiveness, and there was also variation in the results obtained with the same treatment applied in the same month in different years. There was little suggestion of any difference in the effectiveness of D.C.P.A. and T.C.P.A., except in the case of *E. tessellaris*, and the different formulations used appeared to be equally effective. This is in contrast with the findings of Easterbrook (1951), who, from concurrent work on several species of eucalypts in south-east Queensland, reported poor kills with salts and esters of D.C.P.A. but 85 to 90 per cent. kills with salts and esters of T.C.P.A., all of which were applied at 1.0 per cent. acid equivalent.

Further work along these lines is not contemplated at present because poisoning eucalypts with any compound can at best give only temporary control of regeneration until it is allied with pasture development. Until this time, however, and especially on poorer country and on steep slopes, landholders will probably be obliged to poison and they will therefore have to weigh the greater consistency of results with arsenic against the absence of toxic effects to operator and grazing animal where phenoxyacetates are used. Comparison of costs is complicated because of wide variation in the price of different proprietary brands of the phenoxyacetates, but compounds are available at prices (as at August, 1953) such that 1% sodium D.C.P.A. is slightly cheaper than 12.8% As_2O_3 or 20% As_2O_5.

In forestry work phenozyacetates may also have an advantage over arsenic in thinning operations on regeneration stands of eucalypts. Where arsenic is used for this purpose trouble is experienced with some species in that untreated trees are killed or damaged by transference of arsenic from treated trees. This was observed in experiments with *E. tessellaris* where arsenic was used, but not where phenoxyacetates were used.

Acknowledgment

It is desired to thank Mr. W. J. D. Shaw for facilities at "Rodd's Bay" and much skilled help in the experiments conducted there, and Mr. J. C. Thompson, of "Ban-Ban", and the Gatton Shire Council for facilities.

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TECHNICAL NOTES

THE CONTROL OF LIGHT BROWN APPLE MOTH (*TORTRIX POSTVITTANA*) OF CANNING PEACHES WITH DICHLORODIPHENYL DICHLOROETHANE (D.D.D.).

Light brown apple moth is indigenous to Australia and attacks many fruit crops, including late canning peaches on which it can cause extensive surface damage. Besides causing fruit to drop, heavy infestations can aid the rapid spread of brown rot due to the entry of spores into the damaged parts of the fruit. Light brown apple moth is not controlled by D.D.T. (Lawrey, 1949; Stephens, 1948) and it is possibly the heavy applications of D.D.T. for control of Oriental fruit moth (*Cydia molesta*) which has caused its rapid increase in severity on Goulburn Valley peaches over the past few seasons. Light brown apple moth is controlled on apples and pears by arsenate of lead sprays, but this chemical cannot be used on peaches owing to the risk of severe defoliation. There is, therefore, no satisfactory method of controlling this pest in peaches by chemical means.

Following trial work in New Zealand (Taylor, 1952) where D.D.D. was successful in controlling light brown apple moth on apples, trials were initiated in the Goulburn Valley of Victoria to determine the effectiveness on this pest on peaches. The effect of D.D.D. on Oriental fruit moth was also investigated.

Experimental Details

Two trials were arranged on Pullar cling peaches at Shepparton East. The first was a small replicated one in which four chemicals, including D.D.D., were tested and the second was on a larger scale where D.D.D. and D.D.T. were used jointly and separately for control of both light brown apple moth and Oriental fruit moth.

Trial 1

This trial consisted of 4 single tree treatments plus control replicated 4 times. The chemicals were D.D.D., Endrin, Lindane and Dieldrin, and all were applied at the concentration of 0.1 per cent. active ingredient. Trees were sprayed at peak emergences of light brown apple moth, as determined by lure pot counts, a total of 5 applications being made through the season. The usual D.D.T. sprays for control of Oriental fruit moth were applied independently.

Trees were stripped of fruit at harvest and all fruit, including that which had fallen, was assessed for light brown apple moth. In order to analyse the data from this trial it was necessary to transform the values. The variable analysed was log_{10} (*number attacked*$+1$)—log_{10} (*total number*$+1$), or log_{10} (*approximate % attacked.*) Significance is based on the transformed data, and approximate percentages are given for reference only. They are obtained by transforming back, and are therefore geometric means of original percentages.

The only significant differences found in the means are between the control and either Endrin or D.D.D. The means and differences required for significance are given in Table I.

Trial 2

In view of the difficulties associated with small plots in orchard spraying to

TABLE I.

Effect of treatments on light brown apple moth at harvest.

Treatment	% attacked (approx.)
Control	6.4 (0.806)
Dieldrin	2.4 (0.389)
Lindane	1.9 (0.281)
Endrin	0.8 (—0.124)
D.D.D.	0.8 (—0.117)

Note.—Logarithmic values given in brackets. Differences required for significance:—
5% level .... (0.61)
1% level .... (0.84)

control insects which travel considerable distances, larger sized observation plots were laid down. In a large block of Pullar cling peaches, block A of 30 trees was sprayed with D.D.T. plus D.D.D., and block B of 24 trees was treated with D.D.D. only. The remainder of the block, block C, received the usual D.D.T. sprays for Oriental fruit moth. Sprays were applied at peak emergences, a total of 5 sprays being applied in each case. Both D.D.T. and D.D.D. were applied at a concentration of 0.1 per cent. active ingredient.

At harvest 4 trees in the centre of blocks A and B, and 4 taken at random in block C were stripped of fruit and counts for both light brown apple moth and Oriental fruit moth were made. The results are given in Table II.

It is clear from the results that D.D.D. gives virtually 100 per cent. control of light brown apple moth of peaches reducing a moderate infestation of 11.3 per cent. in the D.D.T. plot to nil.

It is also apparent that under the conditions of the trial the omission of D.D.T. from the spray on block B did not increase the infestation of Oriental fruit moth. However, the repeated applications of D.D.T. over the rest of the orchard could have made it very difficult for Oriental fruit moth to penetrate. On the other hand Oriental fruit moth were caught in the lure pots set in the centre of the blocks.

Further trial work is therefore necessary to determine whether D.D.D. applied on a large scale will control both Oriental fruit moth and light brown apple moth.

Conclusions

It has been shown that D.D.D. at a concentration of 0.1 per cent. gives excellent control of light brown apple moth on Pullar cling peaches. Endrin is also promising and should be tested further, but both Lindane and Dieldrin are ineffective.

D.D.D. may also be effective in the control of Oriental fruit moth, but further trial work is necessary to confirm this.

Acknowledgments

Our thanks are extended to Messrs. R. Roberts & Son and Mr. H. Guppy, on whose properties these trials were carried out, and to Dr. E. J. Williams, C.S.I.R.O., Division of Forest Products, who conducted the statistical analysis.

TABLE II.

Large scale trial showing the effect of treatments on light brown apple moth and Oriental fruit moth at harvest.

Block	No. of Trees	Treatment	% Light brown apple moth	% Oriental fruit moth
A	30	D.D.T. & D.D.D.	0.0	0.42
B	24	D.D.D.	0.07	0.5
C	Remainder	D.D.T.	11.3	1.1

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RUST ON *EUPHORBIA PEPLUS* L.

During recent months, the Rust *Melampsora euphorbiae-pepli* W. Müll. has been found on *Euphorbia peplus* in Victoria.

The first collection of *M. euphorbiae-pepli* was made in 1902, in Europe where *E. peplus* is indigenous (Muller, 1907); but there is no previous record of its occurrence in Australia. The host plant, on the other hand, is widely spread throughout temperate Australia and, as early as 1873, *E. peplus* was recorded as naturalized in Victoria (Ewart, 1930).

During the autumn of 1954, specimens of *E. peplus* infected with rust in the *uredospore* stage were collected by Dr. E. I. McLennan, of Melbourne University. A few weeks later, in June, 1954, more rust-infected plants of *E. peplus* were collected at Burnley Gardens, Melbourne; both *uredo* and *teleutosori* were present on these specimens.

The infected plants were rendered very conspicuous by the development of "Mikado orange" (Ridgway, 1912), small, round *uredosori* on the lower surface of the leaves.

The echinulate, "yellow ocher" (Ridgway, 1912), *uredospores* were mostly spherical in shape with an average diameter of 16 μ, or in instances where the length was greater than the width, measurements ranged from 16-20 μ in length x 14-16 μ in width. Thick-walled hyaline paraphyses, with inflated globular heads measuring 20-24 μ in diameter, were inter-mixed with the *uredospores*.

The *teleutosori* were less obvious than the *uredospore* pustules being "blackish brown (3)" (Ridgway, 1912), in colour. These *teleutosori*, which were found on the stems only, were linear in shape, ranging from approximately 2 mm. to 1 cm. in length.

The thick-walled, "tawny" (Ridgway, 1912), columnar *teleutospores* measured 44-64 μ in length x 8-12 μ in width. These spores were closely packed together in a sorus, which was covered over by one epidermal and one or two sub-epidermal layers, of cells.

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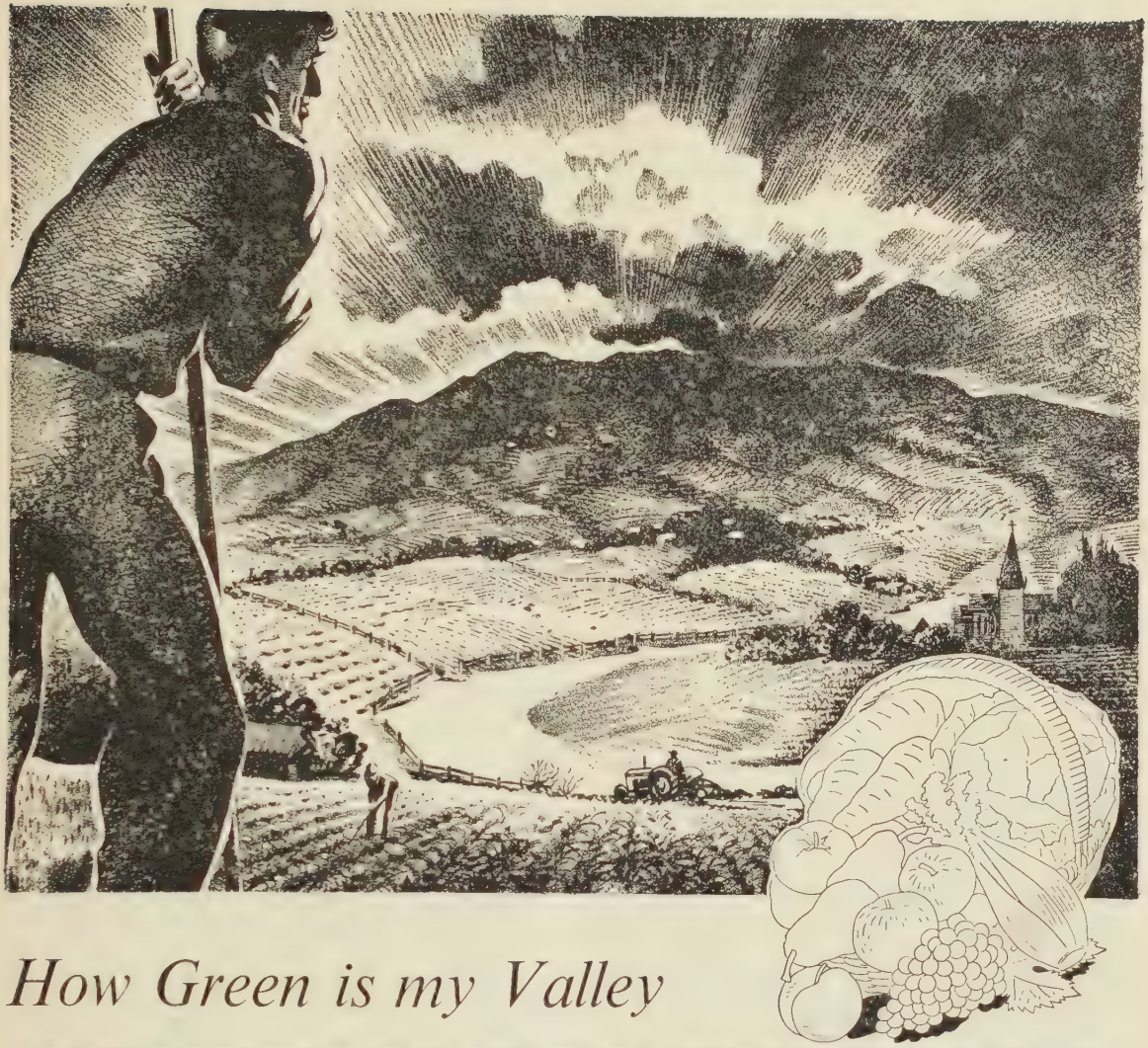

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BRANCH NOTES

Australian Capital Territory

The Annual General Meeting of the A.C.T. Branch was held on March 29, when the retiring President, Mr. C. S. Christian, delivered his Presidential Address entitled "Underdeveloped Regions".

The following office-bearers were elected at the meeting:—

President: *Mr. R. M. Moore.*
Vice-President: *Dr. D. B. Williams.*
Honorary Secretary: *Miss M. Mills.*
Honorary Treasurer: *Mr. C. I. Davern.*
Honorary Sub-Editor: *Mr. T. G. Campbell.*
Committee Member: *Mr. P. A. Reid.*

A recent alteration to the Branch by-laws increased the size of the Committee and *Mr. C. S. Christian,* the retiring President, and *Mr. T. T. Colquhoun,* have also become members of the Committee following this amendment.

At a General Meeting on June 9, Dr. F. H. Morley addressed the meeting on "Genetic Improvement of Merino Sheep". The results of research on the inheritance of important economic characteristics of merino sheep were described. Most characteristics are strongly inherited so that mass selection will usually be far more efficient than complex systems such as formal selection and progeny testing. Important limitations on rate of improvement are inaccuracy of measurement and to a less extent antagonism between desirable characteristics (e.g., fleece weight and fineness). Ordinary classing methods are probably only 40 per cent. accurate and could be replaced or supplemented by the use of actual measurements. If this were done, annual genetic improvement of the order of 1 per cent. could be achieved. This may be compared with the present rate of improvement which is less than 0.5 per cent. per annum. Methods of using measurements in flock improvement programmes were discussed.

On July 17, Dr. M. R. Jacobs, Principal of the Australian Forestry School, addressed a General Meeting on the subject "Wood as a Crop from Private Land". Dr. Jacobs pointed out the significance of the tree as a crop from private lands and outlined some ways in which trees on the farm are of direct significance in the timber industry. Trees may be grown on the farms to supply part of the timber supply for use on the property, to produce logs for sale to the timber industry itself and to provide fuel. Dr. Jacobs also discussed possible reasons for inadequate action being taken in Australia to replace trees on private land.

New South Wales

The April meeting of the Branch took the form of a symposium on "The Colombo Plan and World Food Problems", which stimulated more than the usual amount of discussion. There were four speakers, two from Australia and two from Asia. The emphasis in food problems in Asia is almost entirely on quantity. However, with the present rate of technical development in food production in Asian countries the prevention of famines is in sight and soon it will be possible to pay much more attention to improving the quality of the food.

Mr. I. Butler, Economist, of the Commonwealth Bank, opened the symposium with a review of world food problems. The food consumed in Australia is equivalent to about 3,000 calories per head per day while 60 per cent. of the world's population receives no more than 2,200 calories. F.A.O. has estimated that, on a world basis, there will still be considerable shortages of food in 1960, but confined almost entirely to Asian countries. It is a sobering fact that the world's population is increasing at the rate of one million extra mouths to be fed every 10 days. Marketable surpluses of food, lamentable as they are, fall far short of the world shortage of food. The Colombo Plan is concentrating on helping the needy countries to increase their own production; import of food by purchase or gift is only a temporary expedient.

Mr. Syed Waliullah, Press Attache, Pakistan Government, said that the fear of over-population had been overplayed. For example, Australia had only 1.7 per cent. of its area under food crop cultivation. The Colombo Plan, which was initiated by Australia, has already played an important role in Pakistan and is setting a new standard in international co-operation and goodwill. The big Thal project will convert to food growing a desert of 5 million acres, already 1½ million acres are under irrigation.

Mr. D. Chenoweth, a Commonwealth Government Administrator, agreed that the most important thing about the Columbo Plan is its basis of mutual co-operation, and contribution according to prosperity. The Plan is divided into (a) An Economic Development Programme totalling £A31.25 million, and (b) A Technical Assistance Programme totalling £A3.5 million. Australia is providing one-third of the technical assistance in the form of equipment, trained personnel and exports. Training awards and scholarships are given to a wide category of people. So far there have been 410 trainees in Australia of which 100 were agricultural.

Mr. Mohamed Ameer, a senior Government official from Indonesia, who is studying economics in Australia, outlined the differences between Australian conditions and those in Indonesia. Very few Australian methods could be applied in Indonesia and the capacity of the Indonesian community to absorb new techniques is very limited. Education is the big problem.

At the meeting on June 17, the main business was an address by Dr. E. T. Edwards, of Messrs. Houghton & Byrne Pty. Ltd., entitled "Some Recent Developments in Agricultural and Industrial Pest Control". Dr. Edwards stated that, while his recent trip to the U.S.A. and Europe was basically for business reasons, he had been able to see something of the major developments in pest control overseas.

The wide use of methyl bromide as an industrial fumigant was striking and its use is being extended rapidly in the agricultural field. It is comparatively safe and simple to use. On the west coast of America and in Hawaii whole homes and commercial buildings have been encased in plastic sheeting and fumigated for the control of dry wood termites. For greenhouse and seedling box work in the U.S.A. methyl bromide fumigation is becoming standard practice. Treatment is done under plastic sheeting covers. It gives a complete kill of weed seeds (including onion weed, nut grass and oxalis corms and tubers), practical control of damping off and a high kill of nematodes. Parathion is used more widely in America than here and the toxicity hazard is reasonably low. The two recently developed insecticides, aldrin and dieldrin, have proved very effective for the control of soil-inhabiting insects. Aldrin can be applied with fertilizer or as a dust or spray and harrowed in and has not proved phytotoxic to any plant so far tested. For soil work dieldrin, though more expensive, is more effective with a greater residual effect. It is ideal for treating pasture and turf and for mosquito control in swamp lands and rice fields. Endrin, an isomer of dieldrin, is ideal for the control of tobacco pests and is the only insecticide known which does not affect the quality of the leaf.

In view of the huge grain surplus in North America considerable attention is being given to methods of grain fumigation: liquid fumigants, usually mixtures of ethylene dibromide or ethylene dichloride and carbon tetrachloride, are sprayed evenly over the surface of the grain and the vapours penetrate vertically as much as 25 feet but not at all horizontally.

Substantial progress has been made in the U.S.A. in the control of plant-attacking nematodes. For short-term crops they can readily be controlled by soil treatment with D.D. (a mixture of dichloropropene and dichloropropane) or ethylene dibromide before planting. The latter is usually the more effective. In Europe and England pest control work is not as advanced as in the United States.

Queensland

At the May meeting, Mr. L. J. Rogers, Silviculturist of the Queensland Sub-Department of Forestry, addressed members on "Forestry in Southern Brazil". The speaker dealt mainly with the plateau country to the west of the Serra do Mar where the vegetation consisted originally of (a) tropical rain forest, (b) rain forest with Parana Pine (*Araucaria angustifolia*) and (c) treeless grassland.

Large areas of tropical rain forest have been converted to coffee plantations and idle devastated forest lands exist here. Plantations of eucalypts are being established, already totalling 600,000 acres. Usually plantations are managed on a coppice system with a 7-year rotation for the production of fuel and pulp wood. On a longer rotation, the eucalypts are used for railway sleepers, fence posts, poles and logs.

The Parana Pine forests have been used for many years, and the life of remaining stands would not exceed 40 years. Re-afforestation of these areas is now proceeding. The treeless grasslands are being used for pine plantations. The topography allows ploughing and cultivating, followed by direct seeding. An area of 6,200 acres was planted in 6 weeks.

In June, Mr. G. Hubble, of the C.S.I.R.O. Plant and Soils Laboratory, spoke to members on some aspects of soil reclamation and conservation which had come to his notice during an overseas visit.

At the meeting in July, members were addressed by Mr. Douglas Poulsen, a farmer in the Cooroy district of Southern Queensland. Mr. Poulsen was awarded a Nuffield Foundation Travelling Scholarship for Farmers in 1953, and spent eight months in Great Britain. Mr. Poulsen described and illustrated the reclamation and development of land for grass farming in the mountains of Wales, in areas of open-cut mining, in heather country in Scotland and in forest areas. The use of fertilizers, grassland management and grass conservation were discussed in detail.

South Australia

At a meeting on June 11, Mr. H. J. Lee, of the C.S.I.R.O. Division of Animal Nutrition, spoke on the "Aetiology of Phalaris Staggers in South Australia".

Work in South Australia was commenced in 1949, when three areas of 27 acres of subterranean clover, lucerne and sub. clover and lucerne and phalaris respectively, were stocked with mated ewes. Staggers occurred only on the areas where phalaris was present and it was assumed that this plant was responsible. Some of the sheep on this area were dosed with cobalt. It was found that none of the 10 sheep drenched with cobalt developed staggers, but 11 out of 15 not drenched did so. Similar results were obtained in the following year and it was shown that a dosage rate of 28 mgs./week gave protection against staggers but that 280 mgs./week failed to give protection.

An hypothesis that Co ensured the elaboration of B_{12} in the rumen was put forward and a further experiment using sheep from Co deficient country was made using the following treatments: (a) drenched with Co; (b) B_{12} administered orally (200 micrograms 3 times/week); (c) B_{12} administered intramuscularly; (d) nil. Staggers was found to occur equally in all but the cobalt treated group. It was further shown that intravenous Co had no effect and this meant that the function of Co was not in the bloodstream tissues or gut. It was thought that the function of Co was in the rumen but not by way of B_{12}, but that Co affects ruminal flora qualitatively and quantitatively.

In an area of originally virgin scrub which was cleared and sown to phalaris, cases of staggers occurred from mid-May to mid-September. In January, 1953, 150 acres of phalaris and sub. clover were sprayed with aqueous $CoSO_4$, at the rate of 1 lb./acre. This and a control area were stocked in April. It was found that 10% of sheep in the control area developed staggers, but none occurred in the treated area. This year (1954) one case has been reported so far from the untreated area.

It appears that species other than phalaris have a profound effect on the incidence of staggers, and on the toxicity of phalaris itself. Protection in a mixed pasture may be due to (a) dilution of a toxic principle, (b) ingestion of additional Co or (c) protection of the ruminal flora.

Top dressing might push up the concentration of Co in the pasture. If this small additional oral dose prevents staggers top dressing at the rate of 1 lb./acre may also be of use.

On July 9, Mr. C. R. Kleinig, of the Agronomy Department at the Waite Institute, spoke on "Pasture Production Experiments at Delamere". Mr. J. R. Harris, of the Soil Microbiology Department, then spoke on microbiological aspects of this trial work, with emphasis on the problem of "stalling" of subterranean clover.

Mr. Kleinig explained the vegetation and soil type of the area, pointing out the similarity to soils of the Kangaroo Island group. Field trials were described in which varying forms and rates of phosphate and lime were applied to sub. clover. Yield responses were obtained to increasing phosphate and were varied according to the form of lime and phosphate used. Other field work was carried out in conjunction with the Soil Microbiology Department to compare rhizobial inoculation under different conditions. Pot culture work was designed to try and determine the nature of the lime response. No evidence was produced to attribute it either to calcium deficiency or pH response. Trace element mixtures did not affect the lime response. Discussion took place, particularly on the importance of placement effects and interpreting rates of application of fertiliser.

Mr. Harris outlined the problem of clover stalling and discussion took place on the relationship of nutrition level of the plant and pathogenic soil micro-organisms.

Tasmania

At the last General Meeting of the Tasmanian Branch, members heard a very interesting address by Mr. R. A. Scott, of the Department of Agriculture. Mr. Scott visited the U.K. during the 1953 apple season to report on the landed condition of the Tasmanian crop, and returned to Australia via the U.S.A., where he observed various aspects of the apple industry. Mr. Scott dealt with the marketing of fruit in the various English ports and particularly with the London Markets, where fruit is sold by auction or by private treaty. Disorganised and irregular shipping seems to have been the main cause of any faults in the landed product. Timing of the arrival of shipments is most important in obtaining a good price. The main features of the growing and marketing of American fruit were also described. Here advertising is a big feature of the selling campaign.

Mr. Scott then showed a film which was produced in the U.S. and used there to promote apple sales. It dealt with the apple industry in the State of Washington.

Victoria

The nineteenth annual general meeting of the Branch was held on May 28, when Mr. R. G. Downes gave the Presidential address. Mr. Downes spoke on "The Assessment of Land for Development, Improvement and Conservation", stressing the need for this particular stock-taking of the soil and its environment before projects were started. This applied whether the project under consideration was a proposed irrigation scheme, or re-afforestation, or whether it was what was to be done with a particular paddock. The problems of Land-Use Assessment are economic, and environmental, the latter covering soils, topography, vegetation and climate. Agriculturists should maintain a broad view of their particular problems, and use the ecological approach both in agricultural research and practice.

On July 30, Mr. D. S. Bright gave an address on "Some Impressions of Agricultural Engineering in U.S.A. and U.K." Mr. Bright discussed the use of aircraft in agricultural operations, the building of specialised machinery for special jobs, including the hydraulic tractor, and the problems of traction engineering and tractor testing. Mr. Bright commented favourably on agricultural enginering research in the U.K., and the awakening interest in the subject here in Australia.

Sub-Committees

It was with great pleasure that Mr. Downes, one of the prime movers of the project, was able to give the reports of the various sub-committees at the annual general meeting. Other Branches may be interested in these progress reports.

Agricultural Education: The charter of this sub-committee is "To enquire into the various aspects of agricultural education and to make recommendations concerning changes which would be desirable for specific reasons". Over a period of time it is expected to cover four fields—Primary and Secondary Schools, Agricultural Colleges, Universities, and adult farmers.

At present the sub-committee is giving attention to the importance of financial assistance during undergraduate education, the need for glamorising agriculture as a profession, and the improvement of the teaching of biology in boys' schools. It is also trying to ascertain whether agricultural teaching staffs can agree on certain basic minimum courses which should be covered by all graduates.

Agricultural Engineering: This sub-committee prepared a statement for C.S.I.R.O. to assist in its deliberation on the subject during May,

1953. The Australian Institution of Engineers has now appointed a standing technical sub-committee for Australia on Agricultural Engineering with G. H. Vasey as its convener, and this sub-committee is exploring the field with the Victorian Branch Committee of the A.I.A.S.

Agricultural Notebook: Substantial progress has been made in the compilation of the material for the Notebook which is modelled on Primrose McConnell but revised for Australian conditions. Members from other States are contributing material.

Conservation of City Wastes: This sub-committee was appointed in response to a request by the Chamber of Agriculture to the A.I.A.S. for investigation of whether there is a practicable means of supplementing the supply of organic manures available to farmers by utilising composted garbage and sewage. Members of this sub-committee have been co-opted from the various Departments interested in this problem and meetings have been held. Information on the latest overseas developments is being obtained.

Publicity and Public Relations: This sub-committee was responsible for the production of the brochure "Careers in Agricultural Science".

A Programme Sub-Committee has been functioning for the past eighteen months to co-ordinate meetings of the Melbourne University Agricultural Society, the Australian Society of Animal Production and the A.I.A.S. In Victoria all Institute members are automatically members of the M.U.A.S. which arranges meetings by local speakers.

Salaries and Status Sub-Committee has been in existence for a number of years. Its activities are hampered by the fact that the Victorian Public Service Board does not hear any professional associations. It was for this reason that an attempt to make a concerted move for a separate salaries schedule, restricted to officers eligible for corporate membership of the recognised associations, lapsed in 1953.

The Social Sub-Committee organises the Annual Dinner and Welcome to New Graduates.

Undergraduate Affairs: *This sub-committee* invited members of the fourth year of the course to meet them to discuss progress with their course and their employment preferences. Eighteen undergraduates were interviewed individually, firstly on August 11 and 13, and again on December 2 and 3. The students expressed their appreciation of this Institute interest in their welfare and the sub-committee is meeting students again this year. The members of this sub-committee comprised representation of the major employing bodies and Prof. Wadham.

Newsletter: The Victorian Branch continues to produce a newsletter about every two months to keep members informed of Institute activities.

Western Australia

On June 18, Mr. D. P. Drover, Lecturer in Soil Science at the University of Western Australia, addressed a well-attended meeting, his topic being "Crop Rotation and Soil Nitrogen in the Wheatbelt of Western Australia".

Mr. Drover outlined the present soil fertility status of the wheatbelt; most of the soils are much lower in nitrogen than other Australian and overseas soils; evidence was also given for decline in chemical and physical soil fertility where pasture legumes are not established. Mr. Drover then outlined the soil research programme at the Institute of Agriculture dealing with soil nitrogen, organic matter, and structure in wheatbelt soils. A co-operative experiment at Wongan Hills was undertaken with the C.S.I.R.O. and Department of Agriculture, to discover the grazing capacity, wheat yields, and soil changes under five four-course rotations. The two cycles analysed showed that subterranean clover pasture led to most increases in soil nitrogen, with which were correlated increases in wheat yield and protein content. Annual cultivation appeared to lead to decreases in soil nitrogen.

Soil analyses of rotation experiments established by the Department of Agriculture in 1929 showed the low fertility of both virgin soils, and soils after 22 years in which a legume crop was grown for half the four-course rotation. The structure of the soils also became poorer under shorter rotations; longer periods under legumes were needed.

Mr. Drover then discussed the lack of data on nitrogen balance of Australian soils, and outlined the lysimeter technique, use of which was being made at Muresk, where 24 lysimeters, containing two soil types under four rotations, were built. The first results suggested a large leaching of nitrogen, especially from light textured soils. Mr. Drover concluded that the nitrogen status of coarse textured wheatbelt soils may be difficult to improve, due to both the environment and the soil types present.

A business meeting on July 16 adopted a completely revised set of Branch By-laws. This was the first comprehensive revision undertaken since the formation of the Branch, and was ably executed by Messrs. E. Munch-Petersen and M. M. H. Wallace.

A large crowd attended the opening of the new C.S.I.R.O. buildings, situated in the grounds of the Institute of Agriculture, on August 17. The two buildings now accommodate officers of several divisions, closely grouped for the first time in this State.

PERSONAL NOTES

Australian Capital Territory

Dr. N. P. Kefford has joined the Plant Physiology Section of the Division of Plant Industry, C.S.I.R.O., at Canberra, as a Research Officer. Dr. Kefford recently spent six months in the United States with Professor Thimann at the University of Harvard after completing two years of his C.S.I.R.O. studentship at King's College, London, with Professor T. A. Bennett Clarke, F.R.S.

New South Wales

Mr. W. D. Kerle, agronomist and maize specialist in the N.S.W. Department of Agriculture, has retired after 42 years' service. Representatives of the maize growing industry recently gave a luncheon to Mr. Kerle in recogtion of his work in introducing hybrid maize to this State.

Mr. A. J. Meers has returned to the Department of Agriculture after 18 months in England studying cereal chemistry. He spent some time with Allied Bakeries Research Laboratories Ltd., familiarising himself with the bread-making quality of wheats from various parts of the world. A short period was spent with Dr. Kent-Jones and with a manufacturing firm specializing in mill and flour-testing equipment. Mr. Meers will be working on the bread-making quality of wheat at the Wagga Agricultural Research Institute.

Mr. W. L. Morgan has resigned from the Entomological Branch of the Department of Agriculture, after many years' service, and has gone into the commercial rhizobium field.

Mr. R. H. Harris, formerly lecturer in Food Technology at Hawkesbury Agricultural College, is also producing *Rhizobium* cultures commercially in large quantities.

Queensland

Mr. A. F. Bell, Under-Secretary, Department of Agriculture and Stock, Queensland, has been appointed a member of the recently formed Advisory Committee, to advise the State Developmental and Public Works Council of Ministers. The purpose of this Council is to plan the allocation of loan funds to developmental and public works. Agriculture is thus given a direct voice in the central planning of development of Queensland.

Mr. R. C. Colbran has resigned from the C.S.I.R.O. to accept an appointment with the Queensland Department of Agriculture and Stock. Mr. Colbran recently was awarded the degree of Master of Agricultural Science for his work on nematode parasites of apple roots in the Stanthorpe district.

South Australia

Dr. C. G. Stephens left recently to visit the Belgian Congo, Northern Rhodesia and South Africa. He will attend the International Soil Science Congress and plans to return on October 4.

Mr. J. C. M. Fornachon, Wine Research Chemist at the Waite Institute, is now in Southern Europe and will follow vintage work to northern European countries during the next few months.

Mr. R. T. J. Webber has resigned from the Education Department and has taken the position of Lecturer in Horticulture at Dookie Agricultural College.

Mr. G. M. E. Mayo has returned to the Genetics Department of the University of Adelaide from his overseas visit.

Tasmania

Mr. C. A. Holland left Hobart recently to travel to the Philippines where he will remain for the next twelve months. Mr. Holland has joined an Education Mission to the Philippine Islands. This was the result of a request from U.N.E.S.C.O. to Australia to supply a Specialist in Agricultural Education.

Victoria

Mr. R. G. Downes, of the Soil Conservation Authority, has been granted a Fellowship by the Commonwealth Fund of New York for study in the U.S.A.

Mr. A. C. Doery has been appointed Officer-in-Charge of Ellinbank Dairy Research Station for the Victorian Department of Agriculture.

Mr. John Landy, a 1953 graduate who is doing much to publicise Australians overseas in the running field, will take up a teaching appointment with Geelong Grammar on his return.

Mr. Lou Sharp is now general manager of the Kiewa Dairying Co. He was with U.N.O. for three years where he was associated with the "Save the Children Fund", in the practical capacity of advising South American countries on drying of milk.

Mr. W. A. Beattie has just published "Beef Cattle Breeding and Management".

Mr. G. Loftus Hills has been awarded the Gold Medal of the Australian Society of Dairy Technology.

Mr. N. McC. Tulloch has returned from the Australian Scientific Liaison Office, London. He is going to the C.S.I.R.O. Regional Pastoral Research Laboratory at Armidale, N.S.W.

Dr. Nancy Millis, Lecturer in Bacteriology, has been awarded a research grant by the American Association of University Women. She will spend fifteen months in the U.S.A.

Sir Ian Clunies Ross was awarded a knighthood in the Queen's Birthday Honours List.

Western Australia

Professor E. J. Underwood, Dean of the Faculty of Agriculture of the University of Western Australia, was elected recently as a

Fellow of the Australian Academy of Science. The honour was accorded to three West Australians.

Mr. A. S. Wild has been appointed to the position of Assistant Superintendent of Wheat Farming in the West Australian Department of Agriculture, left vacant by the promotion of Mr. F. L. Shier. Mr. Wild, a former Branch President, was formerly Projects Officer with the War Service Land Settlement Board.

Mr. G. H. Burvill, Commissioner of Soil Conservation, is representing Australia at the Fifth International Congress of Soil Science, at Leopoldville, Belgian Congo. After the Congress, Mr. Burvill will visit winter rainfall areas in South Africa, and summer rainfall areas in Northern and Southern Rhodesia.

Mr. P. G. Ozanne, Research Officer of C.S.I.R.O., left in August to study plant nutrition problems at the Berkeley Campus of the University of California. He will spend two years in U.S.A., on a C.S.I.R.O. Studentship.

Mr. H. Seeger, an officer of the Chilean Ministry of Agriculture in Santiago, attended the P.I.O.S.A. Congress, and has since gone on to Canberra, where he is working for a month with Mr. W. M. Willoughby.

NEWS ITEMS

Chair of Animal Husbandry—University of Sydney

The Senate of the University of Sydney recently decided to establish a Chair of Animal Husbandry. The Vice-Chancellor, Professor S. H. Roberts, in announcing the decision, said that the problems of animal husbandry were becoming more and more urgent, and they must be solved. A board of studies, comprising members of the faculties of Veterinary Science and Agriculture, will direct the courses and the Professor to be appointed to the Chair will be a member of both Faculties.

The Australian Meat Board, the Australian Dairy Produce Board and the Inter-Departmental Committee on Wool Research have jointly given to the University two farms between Camden and Cobbitty, comprising 780 acres of river flat country, which will be used for animal husbandry work. Improvements costing about £150,000 will be made to the properties.

Pan Indian Ocean Science Congress

The Pan Indian Ocean Science Congress opened in Perth on August 17. Many visitors from overseas countries, and from other Australian States, attended the congress, which included a number of functions and country excursions. Distinguished guest members included Professor J. Millot, of Tananarive, Madagascar; Professor M. L. Oliphant, of the Australian National University; Dr. F. W. G. White, Chief Executive Officer of C.S.I.R.O.; Dr. A. Wolsky, representing U.N.E.S.C.O.; Professor J. W. Wells, of Cornell University. The Congress covered a wide range of scientific fields, the chief interests for agriculturists being the sections dealing with Biological Sciences, Agricultural Sciences and Geological Sciences.

Seventh International Grassland Congress

The Seventh International Grassland Congress is to be held at Massey Agricultural College, Palmerston North, New Zealand, during the second week of November, 1956.

It will last for one week and will be followed by post-conference tours in both the North and South Islands.

The Congress programme comprises twelve half-day sessions and two evening sessions. Each session will consist of a symposium of four papers dealing with a particular aspect of grassland problems and research.

Because the Congress is being held in New Zealand the programme has been deliberately given bias towards New Zealand grassland farming. Many of the sessions will, however, be dealing with subjects of a general nature and an endeavour is being made to secure leading grassland research workers of the world as authors of papers.

Papers will be of a technical nature and will deal mainly with the results of research into problems and practices of grassland farming. Particular emphasis is being laid on the pasture-animal complex because in this some of the most important grassland problems are apparent.

Any enquiries regarding the Congress should be addressed to the Organising Secretary, Seventh International Grassland Congress, P.O. Box 2298, Wellington, New Zealand.

Mr. E. A. Southee Retires

The Principal of Hawkesbury Agricultural College, N.S.W., Mr. E. A. Southee, has retired after 33 years as Principal. Mr. Southee has had a distinguished career. He graduated in Science from Sydney University in 1912 and

continued as one of the first students in the Faculty of Agriculture under Professor R. D. Watt. In 1913, after completing the Agriculture course, he went to Oxford as an Australian Rhodes Scholar and served in the British Army during the 1914-18 War, gaining the O.B.E. At the end of the War he returned to Oxford and gained his M.A., and later spent some time at Cornell University doing research in plant breeding.

During his long association with Hawkesbury, Mr. Southee became one of the best-known personalities in the agricultural world in New South Wales, and built up that institution into one of the leading agricultural colleges in the southern hemisphere. It is of interest, too, that Mr. Southee has had a long association with the Institute, being one of those responsible for its formation.

Mr. H. R. Richardson will succeed Mr. Southee as Principal of the College. Before his appointment as deputy-Principal in 1948, he was Assistant Principal Agronomist (pastures) in the N.S.W. Department of Agriculture.

LETTERS TO THE EDITOR

Sir,

The Training of Agricultural Extension Workers

I refer to a paper by Underwood, Pennefather and Summerville entitled "The Training of Agricultural Extension Workers" in the March issue of the Journal of the Australian Institute of Agricultural Science.

This article states (page 17) that "a move should be made partially within the agricultural colleges . . . for special training in extension methods for Diploma men."

As far as the Hawkesbury Agricultural College is concerned, this is in fact being attempted. In both our 2- and 3-year Diploma courses, instruction in extension methods is given. This pre-service training is covered by a course which includes instruction in :

(a) group contacts—organisation of associations, conduct of meetings, public speaking, debating, field days, demonstrations;

(b) individual contacts—salesmanship, personality, difficult contacts;

(c) methods of publicity—radio broadcasting, press writing, advertising, visual education aids.

This course is on lines similar to those followed by the N.S.W. Department of Agriculture's Extension Methods 10-day Schools. Because of the nature of student class instruction, limitations are of necessity placed upon the practical application of this training. Nevertheless, during the course and throughout their College life, students participate actively in some degree of radio broadcasting, public speaking, debating and conducting meetings.

E. A. SOUTHEE

Hawkesbury Agricultural College,
Richmond, N.S.W.
15th June, 1954.

POSITIONS VACANT

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

Division of Plant Industry.

APPOINTMENT OF ASSISTANT TECHNICAL SECRETARY.

Applications are invited for appointment to a position of Assistant Technical Secretary on the administrative Staff of the Division of Plant Industry.

The Division of Plant Industry now has a staff of nearly 400 persons, including 150 Research and Technical Officers, located at thirteen regional laboratories and field stations throughout the Commonwealth. Research is being carried out in a wide range of plant sciences.

The successful appointee will be stationed at the Divisional Headquarters in Canberra. He will be required to assist in the general scientific administration of the Division. Persons interested in a career in scientific administration are invited to write to the Chief of the Division for details of the duties and prospects.

Applicants should possess a University honours degree in science, agricultural science or related field.

Salary: Dependent on qualifications and experience, commencing salary will be determined within the range of Senior Research Officer, £1,322 to £1,472 p.a. (actual), or Research Officer, £854 to £1,262 p.a. (actual).

Applications, referring to appointment number 130/176, should reach the Chief, Division of Plant Industry, C.S.I.R.O., P.O. Box 109, City, Canberra, A.C.T., not later than 14th October, 1954.

PUBLIC SERVICE OF SOUTH AUSTRALIA

Applications for the position set out hereunder will be received by the Public Service Commissioner, 31 Flinders Street, Adelaide, until and including 14th October, 1954.

Applicants should state full names, address, date of birth, marital status, academic qualifications, practical experience, and give particulars of war service (if any). Copies only of testimonials should be submitted with the application.

The appointee may be required to contribute to the Government Superannuation Fund.

SALARY QUOTED IS ACTUAL AND INCLUDES COST OF LIVING ADJUSTMENTS TO DATE.

Agriculture Department.

PROJECT OFFICER.

(Parndana, Kangaroo Island)

Salary Range: £907-£967 per annum.

Duties: Responsible to the officer-in-charge, Kangaroo Island Research Centre, for the supervision of normal farm operations, including stock husbandry and developmental work; assist in the establishment, maintenance and assessment of field experiments, the compilation of farm records and tabulation of experimental data.

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